Australian Society of Exploration Geophysicists

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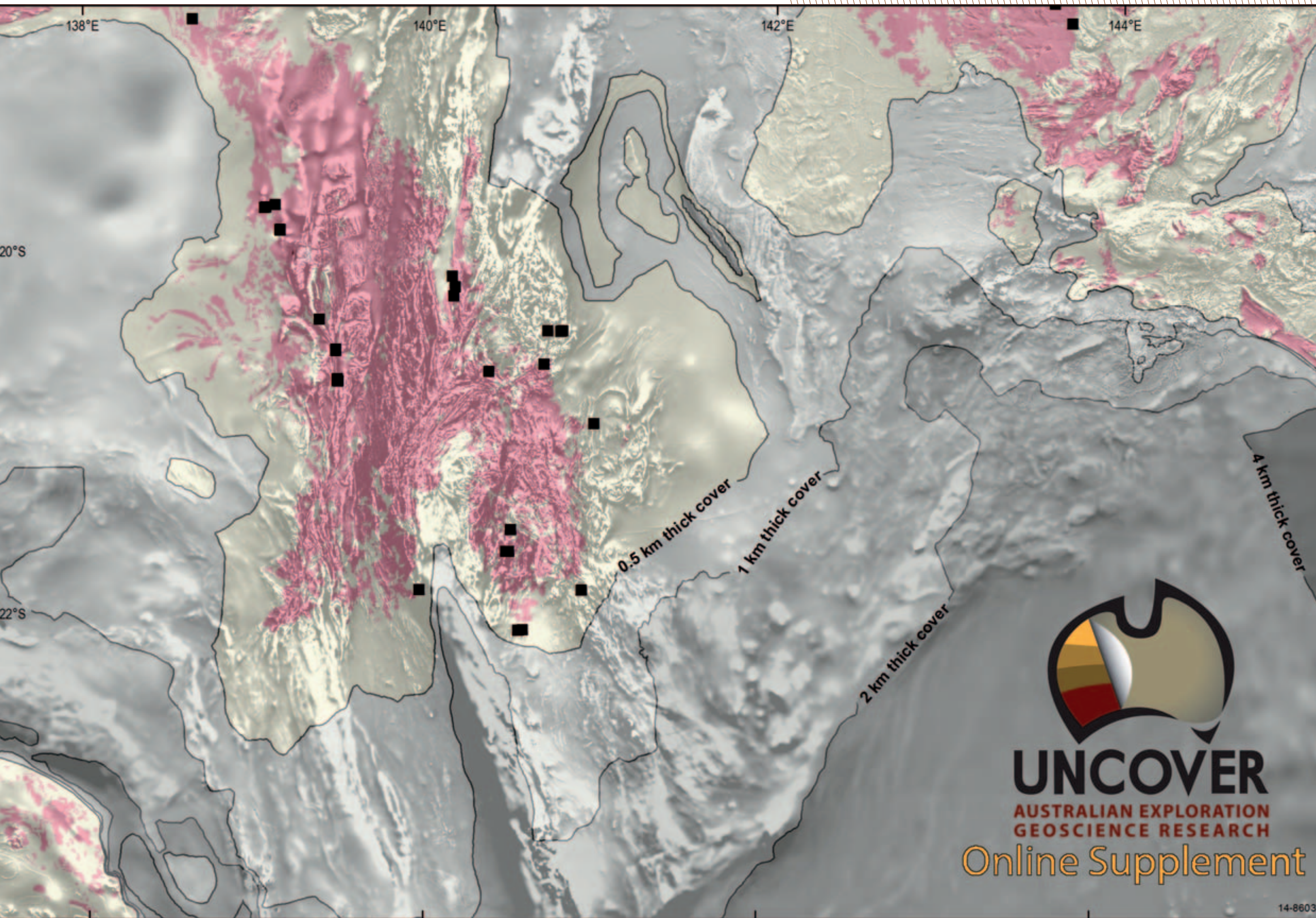
PREVIEW



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FRONT COVER

The cover image, courtesy of Geoscience Australia, is an illustration of the extent of the poorly explored covered regions of Australia compared with the distribution of relatively well-explored outcrop (in pink). Main image shows the detail of a part of North Queensland with the region's geological character of outcropping rocks and basement beneath cover imaged by variability in magnetic response. Major mining operations are clustered either on the outcrop or in shallow cover immediately adjacent to it. This image was also used on the cover of the UNCOVER Summit summary report published in the online Preview supplement : UNCOVER: Unfolding the vision for exploration Geoscience towards a brighter mining future in Australia, Summit 2014 and Next Steps, 2014. *Preview* **172**.

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Lisa Worrall

Thank you to all the *Preview* readers who gave me feedback on the last edition. The feedback was overwhelmingly positive although a number of readers did express concern about not receiving an email alert when the August issue of *Preview* became available online (26 August). It would seem that there was a slip between the CSIRO Publishing cup and ASEG Members' lips. If you didn't receive an email alert then the short term fix is to submit/re-submit a request to receive an alert from CSIRO at http://www.publish.csiro.au/?nid=25&aid=685. In the longer term the ASEG Publications Committee, emboldened by the Federal Executive, will look at improving and, in particular, speeding up online access to *Preview* content.

This issue of *Preview* is bulging at the seams. There is something for everybody from tales of geophysical adventures, a look over Richard Lane's shoulder at a WA workshop on inversion, a how-to guide (on using AEM for potash exploration), the latest from the surveys (including a progress report on deep seismic reflection transects), and yes, as promised, an analysis of the proposed Exploration Development Incentive scheme. The Federal Government obviously hopes that this scheme will give junior exploration companies a much needed injection of funds – and all power to their arm!

Whilst Minister McFarlane is obviously aware that juniors play an important role in making mineral discoveries and ensuring the mining industry has a future in Australia, he is less obviously aware that government sponsored research and development is also important. Roger Henderson gives us an insight into the effectiveness of government sponsored R&D by tracing the history of the development of SIROTEM; a remarkable piece of engineering developed by what was a remarkable team at CSIRO. The development of the TEMPEST AEM system is also a remarkable story, which I hope will be told in a future edition. Sadly, the CSIRO team of geophysicists has largely been disbanded, but we are given a hint of what the future of government sponsored R&D could be in Australia by perusing the presentations given at the UNCOVER Summit and Workshop in Adelaide earlier this year. These presentations are published in their entirety in an online supplement to *Preview* and I would encourage you to take a look.

The next issue of *Preview* also promises to be a bumper edition with Don Emerson providing a marvellous holiday read: 'The Lodestone, from Plato to Kircher'. Speaking of holidays, and of holiday drinking, the SA Branch of the ASEG has taken one for the team, sampled numerous SA wines and selected two for the 2014 ASEG Wine Offer (www.aseg.org.au click on 'Wine Offer'). The selected wines are very good value for money but remember, first-come first-served!

Lisa Worrall
Preview *Editor*
previeweditor@aseg.org.au

The ASEG in a changing world

Nola and I are back from Iceland and I thoroughly recommend the country as a fascinating place to visit. Walking across the fractures of the mid-Atlantic Ridge, descending into an evacuated magma chamber, seeing the immensity of the glaciers – it all added up to an epic trip. The recent eruptions seem even more spectacular now that we have been there. The massive volcanic fields and recent rifts show how the earth is ever changing and will evolve eventually into something very different to what we see today. All this volcanic activity made me sit back and think hard about where the ASEG is going as a society. Are we an anachronism to be 'subducted' and will a new structure or organisation take our place? I hope not, but if the Society is to continue to prosper it must change in an ever changing world.

Every Member of the ASEG Federal executive is cognisant of the Society's objects, as set out in the Society's constitution. I would also encourage you to read the constitution. You will find it at: https://aseg.org.au/images/pages/ASEG%20Constitution%20and%20By%20Laws%20April%202014.pdf.

The constitution states that the ASEG is a learned society and its objects are:

> *... the promotion and advancement of geophysical sciences, especially the knowledge, and its application and continuous professional education, in the areas of exploration geophysics and related sciences.*

Are these objects still relevant? As we are all too well aware, the world is a very different place to what it was when the Society was formed more than 40 years ago. How will new technology and changing paradigms impact on our Society? How will we deliver on our objects in the future?

At the most basic level I am concerned that the future of geophysics is being damaged by a gradual decline in education standards, particularly in science. I find the increasing focus on environmental science over the basic sciences of physics, chemistry, geology and biology particularly worrying. I remember Lazlo Kevi a GSWA geophysicist saying to me that 'the only true science is physics; the rest are merely stamp collecting' but, it would seem that physics is the biggest loser in schools today. I have nothing against environmental science, but I find that too many graduates in environmental science lack basic training in scientific principles as well as in the basic sciences of physics and chemistry. There also appears to be a trend in environmental science towards adopting off-the-shelf solutions rather than towards designing solutions that are a thoughtful response to a problem that has been carefully characterised. I can illustrate the wasteful consequences of off-the-shelf solutions from my personal experience. Environmental scientists thought that planting more trees would fix dryland salinity and planted more trees without a proper understanding of landscape processes in individual catchments. The 'billion trees' program was a failure because trees were not planted in the right places. I understand the tree that Bob Hawke planted died.

How can we as a Society deal with a world where 'scientists' are focused on quick fixes and rush to implement off-the-shelf solutions? Do we sit on our hands or should we get involved? I believe that we should get involved and that we should promote good secondary education. Can we generate an enthusiasm about geophysics in secondary teachers? Adrian Noetzli, a former teacher himself, is planning a workshop for secondary teachers as part of the next ASEG–PESA Conference. It is clear that I am not alone in my concern for the future of our profession because every geophysicist I have asked to present at this workshop has given an instant YES. It would be great to replicate the workshop in other states or to deliver it online.

The lack of understanding of science at secondary level has flowed through to universities. Students are flocking to subjects that promote quick fixes without getting the basic training in science that they will need to properly understand and define the problems they will face in the real world. In addition, changes in the way that universities are funded have seen a decline in the numbers of geophysical staff. In some universities lecturers are merely part time teachers, and in others geoscience is taught with minimal or no geophysical input. I do wonder how useful geologists can be to exploration companies if they have no understanding of geophysics.

The old paradigm that universities were the repository of knowledge and their role was to carry out research and disseminate new ideas no longer applies. Students no longer go to university to 'read' in the classical sense, but to be taught and university staff numbers have been cut in geophysics to the point where academic staff have little time outside their teaching duties to carry out research.

Another issue facing the ASEG is the future of communication technology. From the outset our priorities have been publishing a technical journal (*Exploration Geophysics*), running conferences and publishing a newsletter (*Preview*). Older members like me still prefer hardcopy, but we must move forward. There are good reasons for abandoning the printed medium and moving towards on-line publication. The move will allow us to get copy out to members faster and cheaper. I believe it will also eventually allow us to include more diverse media in our communications to members. For example, we could include video or 3D content in an on-line publication. Printing of colour pages is also an issue for *Exploration Geophysics* contributors and, as a contributor who has just received an invoice of $1000 for colour pages, I believe that contributing to the cost of colour printing may be a significant hurdle for intending authors. We could also consider promoting e-conferences and e-workshops.

Standing in a rift in the mid-Atlantic Ridge in Iceland.

That brings me to a personal observation on the way the ASEG Federal Executive runs. As a group of volunteers we do not have enough time to deal with all the issues facing our Society. There's not enough time for the Federal Executive to focus on strategy, whilst managing core business, whilst struggling to excite and attract the next generation of members and enticing existing ones to stay. So, how do we make sure the ASEG is prepared to meet this and the many other challenges ahead? How do we make our society ready for the future?

We are interested in your views. We will be asking the members to give us feedback on what we should be doing. This may be a survey on-line or it may be a paper survey handed out at the conference. Please participate because we want to hear what you want. Tell us what the ASEG does well and what it does not do so well. If you have any concerns please tell us what is wrong and obviously avoid giving us a solution without defining the problem. The Society is yours as much as ours.

A further concern in geophysics is the move away from larger geophysics departments in large mining houses and government. These departments used to be places where young geophysicists could be mentored and educated into the exploration industry. This role is now taken up by consulting groups but only a small number are large enough to carry a junior workforce. Cost cutting at CSIRO has left so few geophysicists, one wonders if they can be really effective in research. This situation is compounded by cost recovery which forces CSIRO to compete for projects with the private sector.

The latest round of retrenchments at Geoscience Australia has left the organisation with no geophysicists in senior management positions. Can GA be truly effective without senior geophysicists in these times when geophysics is integral to understanding the Australian continent? The situation reminds me of my welcome interview with Alec Trendall when I joined the Geological Survey of Western Australia. The first thing he said was 'Welcome Greg, but we are a Geological Survey and frankly I don't know why we need a geophysicist.' I spent the next 5 years with little to no budget trying to show what geophysics could do for geologists. In that time we flew the first airborne geophysical survey, developed a database of surveys and pushed geophysics into regional geological mapping programs. The efforts of the geophysicists that followed me did dramatically change the Survey such that geophysics expenditure is a now major item in the GSWA annual budget. Is geophysics not one of the major expenditure items in the GA budget? If so, how can GA manage without geophysicists in senior management positions?

If the decline of geophysicists in our research and training organisations continues, then the ASEG will have an important role to play in fostering education and research in geophysical sciences. Perhaps this has always been the case in exploration geophysics because exploration has always about research but, an increasing emphasis on this role will require more resources so that we can develop more effective tools for disseminating and storing knowledge and information. The Society is taking over some of the roles previously held by universities, CSIRO and GA, without the resources and funding that these organisations had in the past. We are an organisation largely run by volunteers who contribute their own time and resources. We need more involvement. We need more members. We need you to get involved in some way if our profession is to grow and, if the Society is going to serve you well, then you need to be part of it. This can be in the smallest way by providing feedback and ideas or greater ways by taking up positions on standing committees, state branches, forming specialist groups or volunteering for the federal executive where strategies are developed. In particular we are looking for people on the education committee and as associate editors for *Exploration Geophysics*. Think about how you can help your profession. It all helps you in the end.

Our profession is expanding and contracting like the earth. New rifts appear, new ideas are formulated, while we move forward in an ever changing world.

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Welcome to new members

The ASEG extends a warm welcome to the following thirty nine new Members. Their membership was approved at Federal Executive meetings in July and August 2014.

Name	Affiliation	State/Country	Grade
George Bernardel	Geoscience Australia	ACT	Active
David Caust	Geoscience Australia	ACT	Active
Dylan Cremasco	Santos	SA	Active
Victoria Gallagher	Santos	QLD	Active
Michael Hartley	CGG	VIC	Active
Josef Holzschuh	Geoscience Australia	ACT	Active
Ashley Howlett	Talisman Energy	QLD	Active
Ross Kleinschmidt	Radiation & Nuclear Sciences, Qld Dept of Health	QLD	Active
Ben Lewis	Geoscience Australia	ACT	Active
Sonia Maunder		QLD	Active
Sarlae McAlpine	Geoscience Australia	ACT	Active
Edith Miller	Chevron	WA	Active
Rory Murray	Fortescue Metals Group Ltd	VIC	Active
Nathan Palmer	Central Petroleum	QLD	Active
Jingbo Wang	Geoscience Australia	ACT	Active
Robert Howard	Case Consulting Pty Ltd	SA	Active
Noori Alavi		WA	Associate
Cameron Mitchell	Geoscience Australia	ACT	Associate
Robbie Morris	Geoscience Australia	ACT	Associate
Alastair Smart	Omnitron Technologies	VIC	Associate
Marcus Haynes	Geoscience Australia	NSW	Associate
Nicholas Badullovich	Australian National University	ACT	Student
Summer Barron	Macquarie University	NSW	Student
Andrey Budniy	Curtin University	WA	Student
Sarah Chamberlain	Curtin University	WA	Student
James Deeks	University of Western Australia	WA	Student
Andy Do	Macquarie University	NSW	Student
Michael Drane	Macquarie University	NSW	Student
Sarah Jayne Evans	Macquarie University	NSW	Student
Sanjay Govindan	Australian National University	NSW	Student
Madeleine Hearnden	Australian National University	ACT	Student
Samuel Henman	Macquarie University	NSW	Student
Anam Mazhar	University of Western Australia	WA	Student
Jarrod McDonald	Macquarie University	NSW	Student
Jack Muir	Australian National University	ACT	Student
Kate Robertson	University of Adelaide	SA	Student
Paul Ssali	Curtin University	WA	Student
Benjamin Stepin	Curtin University	WA	Student
Alexandrea Tuckett	Macquarie University	NSW	Student

ASEG News

New South Wales

In July, we held our annual dinner. Once again, it was held in a steakhouse; we ate lots of steak, drank lots of red, and discussed lots of geophysical and non-geophysical topics. We had a good turnout and a great time was had by all.

In August, **James Austin** from the CSIRO (Mineral Resources) gave a talk entitled 'Lightening, Diesel and Dust: Remanent Magnetism and the Search for Magmatic Nickel Sulphides in Central Australia'. James discussed the magnetic characteristics of the Giles Complex and how they are not fully understood. James then outlined his investigation of the magnetic properties of magmatic nickel sulphide systems and the complexities and problems in trying to understand them. Many questions about the science and the logistics of working in the Musgraves were asked.

An invitation to attend NSW Branch meetings is extended to interstate and international visitors who happen to be in town at the time. Meetings are held on the third Wednesday of each month from 5:30 pm at the Rugby Club in the Sydney CBD. Meeting notices, addresses and relevant contact details can be found at the NSW Branch website (aseg.org.au/nsw/).

Mark Lackie
(NSW Branch President)

Queensland

The Queensland Branch of the ASEG has had quite a social winter in Brisbane. We had the annual Zoeppritz night in July, which started modestly and gathered momentum as the night went on. We also enjoyed a joint ASEG–PESA trivia night in August. Both of these events were well attended by students from our local universities!

We also hosted our most attended event this year to date, with **Dave Hale** presenting his SEG DL '3D seismic image processing for interpretation of faults and horizons'. Dave's enthusiasm was contagious and there were many in the audience bursting with questions at the conclusion of his presentation.

Dave Hale presenting to the Queensland Branch of the ASEG. Note the XXXX beer on hand!

We are getting increasing interest from students attending the local branch meetings and to encourage continuing involvement we have sponsored five students to attend the **Brian Minty** OzSTEP course in September.

We invite any member who is visiting Brisbane to attend our technical meetings and we would welcome offers for technical presentations!

Fiona Duncan
(QLD Branch President)

South Australia and Northern Territory

Since the last edition of Preview, the SA Branch has hosted the annual SEG distinguished lecture. **Dave Hale**, from the Colorado School of Mines, had his audience strongly considering brushing up on their programming skills, with his talk '3D seismic image processing for interpretation of faults and horizons'.

Our annual wine tasting has been run and won. Details of the winning wines can be seen on the order form in this edition of *Preview*. As ever, we think this year's choices are worthy winners, and highlight the diversity and strength of some of SA's lesser-known wineries. Getting an invitation to the Wine Tasting event is quite easy – all you have to do is help out the local ASEG branch; become a sponsor, join the committee, or present a talk at one of our technical nights.

Speaking of sponsors, all of these events are made possible by our very generous group of sponsors for 2014, including Beach Energy, the Department of State Development, Geokinetics, Ikon Science, Minotaur Exploration, Petrosys, Santos, Schlumberger, Statoil and Zonge.

Upcoming events include our annual Industry Night, to be held in late October, and the SEG Near Surface Lecture, by **Dr Koichi Hayashi** whose talk 'Integrated geophysical methods applied to geotechnical and geohazard engineering: From qualitative to quantitative analysis and interpretation' will be held on the evening of Tuesday 7 October, at the Coopers Alehouse.

The Melbourne Cup Luncheon will be held on 4 November at the National Wine Centre, and promises to be another great day. Thanks to Beach for their ongoing exclusive sponsorship.

As ever, new members and other interested persons are always welcome to local events. For further details, please contact Luke at luke.gardiner@beachenergy.com.au or 8338 2833.

Luke Gardiner
(SA and NT Branch President)

Tasmania

The Tasmanian branch is looking forward to hosting the following events in late September and early October:

- **Brian Minty**'s OzSTEP one day course on radiometrics (30 September, CODES Conference Room, University of Tasmania)
- 2014 SEG Near Surface Honorary Lecturer **Koichi Hayashi** (12 noon, 6 October, same venue).

The Branch is also looking forward to a number of honours student presentations towards the end of the year.

Mark Duffett
(Tasmanian Branch President)

Victoria

On Wednesday 6 August the ASEG Victoria Branch enjoyed the *Annual Joint ASEG–PESA–SPE Mid-Winter Social*. As always a good time was had by all!

On Thursday 7 August we were lucky enough to host the SEG 2014 Distinguished Lecture: '3D seismic image processing for interpretation of faults and horizons', presented by **Dave Hale** from Colorado School of Mines. This was a lunch meeting at the Victoria Hotel and a great turn-out ensured many questions following Dave's excellent presentation.

On Thursday 18 September we hosted an ASEG Victoria branch technical evening with 'New developments in airborne gamma-ray spectrometry' presented by **Brian Minty** from Minty Geophysics. The evening meeting was held at the Kelvin Club, and a good sized crowd enjoyed the drinks, nibbles and Brian's well-crafted presentation.

For members who wanted to learn even more about radiometric methods, the opportunity came about the very next day (Friday 19 September) when we hosted the ASEG 2014 OzStep one-day course 'The Gamma-ray Spectrometric Method for Mineral Exploration and

Environmental Mapping', also presented by Brian Minty.

On Wednesday 8 October we will host an evening technical meeting with the SEG 2014 Near Surface Honorary Lecture: 'Integrated Geophysical Methods Applied to Geotechnical and Geohazard Engineering: From Qualitative to Quantitative Analysis and Interpretation', by **Koichi Hayashi** from Geometrics; and on Thursday 23 October we will have the Annual Student Night, where local geoscience students will be presenting their current research. Both meetings will be held at the Kelvin Club, Melbourne Place, off Russell Street in Melbourne's CBD.

We look forward to seeing many ASEG Victoria Branch members at the meetings in the coming months.

Asbjorn Norlund Christensen
(Victorian Branch President)

Western Australia

The WA branch of ASEG has had another round of exciting activity during the first quarter of the new Financial Year.

On the 9 July **Dr Rie Kamei**, Assistant Professor at University of Western Australia, delivered an impressive talk on 'Applications of seismic full waveform inversion'. Dr Kamei briefly reviewed the fundamentals of Full Waveform Inversion (FWI) and illustrated the power of FWI with field examples from a variety of applications.

On 21 July the WA branches of ASEG and AIG participated in the annual Hale School/St Mary's Careers Expo. The night was well attended with exhibitors from local universities and various sectors including finance, hospitality, medicine, real estate, law, health, police and GEOSCIENCE! This year marked our third year at the event and although it was a stormy night, many students benefited from the displays and advice given by the exhibitors. We look forward to an ongoing presence at career events like these, which give us the opportunity to encourage students to study math and science! A total of 75 students and staff attended this Careers Expo.

We hosted **Dr Dave Hale**, Green Professor of Exploration Geophysics at the Colorado School of Mines, as Distinguished Lecturer in one of our regular monthly tech-nights on 12 August. The title of his talk, sponsored by CGG, was '3D seismic image processing for

ASEG WA committee member ***Javad Khoshnavaz*** *manning the ASEG-WA Stall at the Careers Expo.*

interpretation of faults and horizons'. The talk was attended by over 75 people.

Another exciting event was the One-Day Workshop on Geophysical Inversion for Mineral Explorers. More details on this event are presented separately within this edition of *Preview*.

John Joseph on behalf of Kathlene Oliver
(WA Branch President)

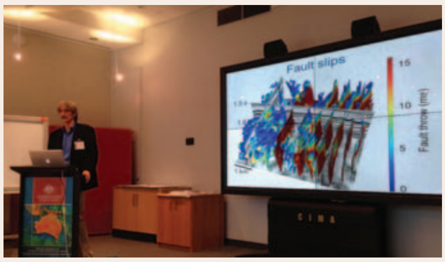
David Hale presenting to the WA branch of the ASEG. Note no beer anywhere within reach.

A large number of geoscientists/explorers attended David Hale's presentation to the WA branch.

Australian Capital Territory

The ACT branch of the ASEG ran a Geo-societies Student afternoon on 18 August at Geoscience Australia. Members of geo-societies spoke about the value of their society to their professional career and how the geo-societies expertise is inter-related. **Millie Crowe** represented the Australian Society of Exploration Geophysicists (ASEG), **Lisa Hall** represented the Petroleum Exploration Society of Australia (PESA), **Emma Mathews** represented the Geological Society of Australia (GSA), **Gabby Yates** represented the International Association of Hydrogeologists (IAH), **Jon Clarke** represented the Mars Society Australia (MSA), **Ian Roach** represented the Australian Regolith Geoscientists Association Inc. (ARGA), and **Paul Kay** represented The Australasian Institute of Mining and Metallurgy (AusIMM). Students were also given a tour of the Australian Tsunami Warning System and afternoon tea, kindly co-funded by PESA. The Geo-societies Student afternoon was a great success – special thanks to **Tegan Smith** (PESA) for MC-ing at short notice and **Millie Crowe** for speaking about the (ASEG) and for her help on the day. Approximately 30 students from the Australian National University and the University of Canberra attended the afternoon.

The 2014 Fall SEG/AAPG Distinguished Lecturer **Dr David Hale** visited on 5 August, his presentation '3D seismic image processing for interpretation of faults and horizons was engagingly presented to nearly 40 people. Dr Hale spoke about new software he is developing that highlights faults in 3D seismic data volumes. This generated a lot of positive discussion days after his talk.



David Hale presenting a faultless talk to the ACT Branch of the ASEG. Note no beer in the ACT either.

Dr Brian Minty kicked off his day long OZstep course in the ACT on 12 September with 16 attending his course:

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'The Gamma-Ray Spectrometric Method for Mineral Exploration and Environmental Mapping'**.** The course offered a valuable insight into the elements of radiometric mapping that affect the interpretability of geophysical data. Brian's knowledge of this topic is second to none and no question was too easy or too hard to elicit a thoughtful answer.

Dr Brian Minty and OzSTEP participants from the Geological Survey of India, Geoscience Australia and ANU.

Sunday 14 September saw another Social Event with members and their families meeting at the National Arboretum Canberra. The Pod Playground proved a hit and I was reliably informed the coffee was great too. The tourist attraction is a must see when in Canberra, with a lovely café and fine dining – for more details see http://www.nationalarboretum.act.gov.au.

ASEG (ACT) SEG Special Lecturer; **Koichi Hayashi** will be speaking on Friday 3 October his talk: 'Integrated geophysical methods applied to geotechnical and geohazard engineering: From qualitative to quantitative analysis and interpretation', will start at 12:30, lunch will be provided for members from 12 noon.

In addition to all the other events and training our members have been busy writing abstracts for posters and oral presentations for the upcoming ASEG–PESA 2015 conference. A special thanks to **Chris Wijns**, **Mike Dentith** and the Conference Secretariat at EECW – the event coordinators, for their help.

Marina Costelloe
(ACT Branch President)
Millie Crowe
(ACT Branch Secretary)

Snapshots from the ACT ASEG Social Event at the National Arboretum in Canberra

Ned Stolz. Note beer in hand.

Bill Jones, Ross Costelloe, Carina Kemp and Phil Wynne.

Ted and Penny Lilley.

Harry Costelloe, Millie Crowe, Attilia Jones and Helena Jones.

Carina and Esmé Kemp.

Leonie Jones, Mille Crowe and Attilia Jones.

ASEG calendar: technical meetings, courses and events

Date	Branch	Event	Presenter	Time	Venue
2014					
15 Oct	NSW	Honours and Masters Students Research Presentations	Various	1800–1900	The Rugby Club, Off 31 Pitt Street, Sydney
20–24 Oct	WA	CET hosted short course on Magnetotellurics	Prof Alan Jones, Dublin Insitute of Advanced Studies		University of Western Australia, Crawley, Perth
19 Nov	NSW	Technical Presentation: Sub-bottom resistivity profiling	Jason Errey	1800–1900	The Rugby Club, Off 31 Pitt Street, Sydney
23 Nov	VIC	Annual Student Night	Various	1800–2000	The Kelvin Club, 24-30 Melbourne Place, Melbourne
04 Nov	SA	Melbourne Cup Luncheon		1200–1630	National Wine Centre, Adelaide
07 Nov	WA	ASEG-PESA WA 27th Annual Golf Classic			TBA
13 Nov	WA	Honours and Masters Students Research Presentations	Various	1730–1930	City West, Function Centre, Perth
Late Nov	SA	Student Honours Night	Various	1730–1930	Coopers Alehouse, Hurtle Sq, Adelaide
10 Dec	WA	WA Christmas Party and AGM		1730 till late	TBA
2014 SEG Honorary Lecturer Near Surface: 'Integrated geophysical methods applied to geotechnical and geohazard engineering: From qualitative to quantitative analysis and interpretation' Koichi Hayashi, Geometrics, San Jose, California. (http://www.seg.org/education/lectures-courses/honorary-lecturers/2014/hayashi/abstract)					
Date	**State Branch**			**Time**	**Venue**
01 Oct	NSW			1730–1900	The Rugby Club, Off 31 Pitt Street,Sydney
03 Oct	ACT			1230–1400	Geoscience Australia, Canberra (Lunch at 1200)
06 Oct	TAS			1200–1300	CODES Conference Room, University of Tasmania, Hobart
07 Oct	SA			1730–1930	Coopers Alehouse, Hurtle Sq, Adelaide
08 Oct	VIC			1800–2000	The Kelvin Club, 24–30 Melbourne Place, Melbourne
10 Oct	WA			1730–1900	City West Function Centre, Perth
13 Oct	QLD			1730–1900	Metropolitan Motor Inn, Spring Hill, Brisbane
2014 OzSTEP: 'Interpreting Seismic Amplitudes' Dr Dennis Cooke, University of Adelaide, Australian School of Petroleum. (www.aseg.org.au)					
Date	**State Branch**			**Time**	**Venue**
25 Nov	QLD			0830–1700	Watermark Hotel, 551 Wickham Terrace, Spring Hill

TBA, to be advised (please contact your state branch secretary for more information).

NOMINATIONS CLOSING SOON!

Nominate a colleague for an ASEG Honour or Award for 2014–15

The ASEG acknowledges the outstanding contributions of its individual members both to the profession of geophysics and to the ASEG, through the presentation of the Society's Honours and Awards across a range of categories. The next Awards are scheduled to be presented at the ASEG–PESA 24th International Geophysical Conference and Exhibition 15–18 February 2015 in Perth, WA.

The ASEG awards are made through nominations from the membership at large, as well as through State and Federal executives. The available awards are:

ASEG Gold Medal

For exceptional and highly significant distinguished contributions to the science and practice of geophysics, resulting in wide recognition within the geoscientific community.

Honorary Membership

For distinguished contributions by a member to the profession of exploration geophysics and to the ASEG over many years.

Grahame Sands Award

For innovation in applied geophysics through a significant practical development in the field of instrumentation, data acquisition, interpretation or theory.

Lindsay Ingall Memorial Award

For the promotion of geophysics to the wider community.

Early Achievement Award

For significant contributions to the profession by a member under 36 years of age.

ASEG Service Awards

For distinguished service by a member to the ASEG.

ASEG members are eligible for all award categories. Non-members also are eligible for the Lindsay Ingall and Grahame Sands awards. Under exceptional circumstances, the other awards may be offered to a non-member of the ASEG who has given appropriate service to the ASEG or to the profession of geoscience, and who has been duly nominated by the Federal Executive.

Nomination procedure

Any member of the Society may submit nominations for an award. These nominations are to be supported by a seconder, and in the case of the Lindsay Ingall Memorial Award by at least four geoscientists who are members of an Australian geoscience body (e.g. ASEG, GSA, AusIMM, AIG, PESA, or similar).

The awards carry considerable prestige within the ASEG and the geoscience profession. Therefore appropriate documentation is required to support the nomination. Nominations must be specific to a particular award and all aspects of the defined criteria should be addressed.

Further details of the award categories and nomination criteria were published in the August 2014 *Preview* and are also available on the ASEG website. *Proforma* nomination forms and further information on the nomination procedures can be obtained by contacting the Chair of the Honours and Awards Committee, Andrew Mutton. All correspondence and nominations will be treated confidentially.

Nominations including digital copies of all relevant supporting documentation are to be sent electronically to:

Andrew Mutton
ASEG Honours and Awards Committee Chair
awards@aseg.org.au or *andrew.mutton@bigpond.com*

Nominations must be received by Wednesday 10 December 2014.

Geophysical Inversion for Mineral Explorers: A report on the workshop presented by the WA Branch of the ASEG on 2 September 2014

This workshop was the second in a series of minerals and near-surface geophysics one-day workshops targeting both geologists and geophysicists that the WA branch of the ASEG is trying to run on a more or less regular basis (the previous occurrence being a one-day workshop on airborne EM run in November 2012).

After throwing around a few ideas for topics, it seemed that geophysical inversion was a natural candidate. Even though it is often accompanied by dreadful formulas and fancy algorithm names, at the end of the day, geophysical inversion is one way (some may even say the only way) to represent large, complicated and sometimes messy geophysical datasets in a plausible geological sense. With available computing power increasing on a weekly basis, 3D environment software becoming more and more accessible to both geologists and geophysicists, and the growing need to compile multiple datasets in a single 3D exploration model, geophysical inversion is well and truly in the spotlight.

Some people asked us if it was worth attending the workshop because they do not usually perform inversions on their geophysical data, especially now their exploration budget has been cut anyway. Our response was simple. The attractiveness of geophysical inversion for an exploration geoscientist is that the cost of inverting old data with new inversion packages is almost insignificant compared with the cost of acquiring new data. And yet, new 'eye-opener' exploration ideas can still spring out of this relatively inexpensive exercise.

Over the course of the day, 90 registrants were shown a great selection of case studies where geophysical inversion demonstrably benefited the geoscientist at various stages of exploration – from terrane scale area selection to resource definition – for a wide range of techniques and commodities. The registrants were also able to spend some time between sessions visiting the sponsors' booths in an adjacent exhibition room. The abstracts for all of the 14 high quality presentations are appended below and the presentations are available for download by following this link http://goo.gl/deJu6o. As a bonus, Richard Lane has generously shared his notes on each of the presentations and these notes are posted on each of the abstracts.

The most positive feedback we received was the fact we managed to keep the registration cost extremely reasonable for this fully catered event ($200 for ASEG and AIG members, $50 for students and $300 for others). This was only possible thanks to our generous sponsors; namely CSIRO, Geosoft, Geotech Airborne, Intrepid Geophysics, Mira Geoscience and SkyTEM Australia. The topic for the next workshop is yet to be decided and we are open for suggestions!

Regis Neroni
rneroni@fmgl.com.au

ABSTRACTS

SESSION 1 PRACTICAL THEORY

An introduction to geophysical modelling and inversion

James Reid, Mira Geoscience

This presentation will give a practical non-mathematical introduction to geophysical modelling and inversion. Forward modelling is the calculation of the expected geophysical response of a given distribution of subsurface physical properties (such as density, magnetic susceptibility or electrical conductivity) for particular measurement parameters (e.g. sensor type and position, component). Forward modelling is an integral part of geophysical inversion, but also has application to survey design, sensitivity analysis, validation of geological models and hypothesis testing. Geophysical inversion refers to the mathematical and statistical techniques for recovering information on subsurface physical properties from the observed geophysical data. Fundamental inversion concepts such as non-uniqueness, regularisation, sensitivity, and data and model norms will be introduced. An overview will be given of different inversion methods, including parameterised inversion, joint inversion, constrained inversion, and statistical (Monte Carlo) approaches. Common applications and pitfalls of inverse methods will also be introduced.

> How do we overcome non-uniqueness? Through incorporation of prior knowledge i.e. by defining characteristics that we would like to see in the inverted model. Mira Geoscience Rock Property Database (RPDB). An impressive resource with more than 6 M measurements – including the GSC database and CRC Handbook values. In contrast to the GA database, which is fundamentally a spatial database, the RPDB is a lithological database. RL

Why different algorithms give different answers

Yusen Ley Cooper, CSIRO

Given the exploration conditions in Australia, where approximately 75% of the terrain is under cover and where outcrop is rare, geophysical exploration methods such as airborne electromagnetics (AEM) can provide us with important geological insights into the subsurface. Although AEM is a technology that emerged and was developed by the mineral exploration industry, for some time now we have witnessed its use in other areas such as groundwater and environmental management and as a tool for regolith mapping. These trends have been accompanied by a need to extract more quantitative information from the measured/observed data, particularly through numerical techniques like inversion. Inversion of geophysical data leads to non-singular solutions, therefore suggests there is the potential of generating a variety of models which can fit the measured data. This ambiguity makes it clear that the choice of processes and algorithms used to interpret geophysical data requires more thought and understanding of the potential sources of these discrepancies. This talk aims to show the use of inversion not as a means of producing a model itself, but how inversion can be used to better understand and assess data, and lead to the optimal goal of gaining data driven geological knowledge.

Yusen asked us 'What is inversion?' It's a way of getting intimate with your dat.a

It's a way of connecting what we measure (i.e. the data) with the essence of the situation (i.e. the model and the forward data transformation) to derive insight into the real world.

The question arose at the end of Yusen's presentation as to how we might define and communicate the degree of confidence that we have in the inversion results.

This was a recurring question through the day, and it is a very difficult ongoing problem. One thing to keep in mind is that the results of sensitivity analyses and probabilistic inversions are 'marginal' or conditional probabilities – i.e. they are conditional on the assumptions in the calculations. Also, they should only be treated as relative probabilities for different scenarios calculated using the same set of assumptions.

Another approach that can be investigated is to consider the 'robustness' of an outcome by inverting a variety of scenarios where we have tried to eliminate the feature through prior information (i.e. constraints such as a reference model that lacks the characteristic or feature in question). RL

Forward modelling and inversion for geophysical survey design

Kim Frankcombe, ExploreGeo

Modern geophysical survey equipment can provide the user with a range of choices regarding survey design. This complements explorers' desires to see deeper and with greater resolution than previously possible. However, these advances are buffered by shrinking exploration budgets which require that every survey offer the maximum return on investment.

In order to try and select the right tools for the problem and the configuration of those tools providing the best value for money, the problem can be modelled prior to the survey. For techniques which provide answers which are not always interpretable directly from the data, these forward models can be inverted to see how well the known starting point can be recovered from the data using the tools and configuration selected. By doing this prior to the survey various designs can be simulated and their effectiveness judged without the expense of trial surveys.

Induced polarisation equipment has advanced significantly in the past 20 years, perhaps more than any other weapon in the mineral geophysicists armoury. This has been coupled with similar advances in IP modelling and inversion software. Data can be acquired, processed and modelled in 3D. No longer are we restricted to acquiring data at a single dipole size or having the dipole size equal the electrode separation. The choices of electrode and dipole layout are infinite but not all choices are equal when it comes to resolution, depth of investigation and cost. Using a modelling and inversion process to test designs can result in surprises and lead to designs which had not previously been considered.

Kim expected more geologists to be attending so he had placed some of the presentation material into appendices. I'm not sure what this implies – perhaps that geologists can read whilst geophysicists need pictures?

I noted that Kim had quite high expectation from inversion in that he was looking for accurate delineation rather than simple detection of a feature. This is a reminder of how far we have come – from bump detection in data profiles, to feature detection through inversion, and now to feature delineation. RL

SESSION 2 CASE STUDIES 1 – PURE PROPERTY INVERSIONS

Magnetics – From the Arctic to the Andes

Michael Webb, Consultant

This presentation consists of three examples of magnetic inversions and forward modelling. The inversions and forward models were mostly performed using Geosoft's Voxi software. The first example is from Anglo American's Sakatti nickel and copper project in northern Finland. This example shows the results of unconstrained magnetic susceptibility and magnetisation inversions and compares these to inversions constrained by magnetic susceptibility measurements on drill core. The second example is from South Australia. It shows the results of magnetisation inversion on an area with strong magnetic remanence (Q > 500) and compares the magnetisation estimated from the inversion with magnetisation measured from oriented core samples. The final example, from Northern Chile, demonstrates the problems of working with magnetics in areas of rugged topography and low magnetic field inclination.

Mike showed examples of Geosoft's MVI results (i.e Magnetisation Vector Inversion). The message was that each program has limitations, and that we must be aware of these. As a consequence of non-uniqueness, a program that only modelled magnetic susceptibility would predict the observed data with more or less the same degree of accuracy as a full magnetisation inversion. However, constraints such as rock property prior knowledge would tell us that one or other of these scenarios was a more accurate reflection of our world. RL

Examples of 3D potential field inversions – low latitudes and remanence

Barry Bourne, Consultant

Recent advances in 3D inversion methods have led to the availability of techniques that look to address more complicated geological/geophysical problems and challenge conventional thinking. One of these techniques, the Magnetic Vector Inversion (MVI) method directly models the vector of magnetisation based only on anomalous TMI data. The method allows the interpreter to model features that may contain a combination of remanent magnetisation, demagnetisation or anisotropy of magnetic minerals. It is shown that at low latitudes the MVI technique appears to have benefits over conventional modelling for porphyry exploration. In addition, at a regional scale, geological features that appear to be normally magnetised may in fact have a remanent component and alternative modelling techniques should be trialled and all data considered before planning follow-up exploration.

Barry showed us some examples of using modelling and inversion to map geological features (i.e. a 3D geological mapping application). Rather than the direct detection of a target, multiple indirect criteria could be applied to the 3D geological map to derive targets. RL

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Joint inversion of MT and DC data over Olympic Dam IOCG deposit

Peter Rowston, GRS

Geophysical Resources and Services have been running combined magnetotelluric and controlled source resistivity surveys as a standard service for over ten years. In the great majority of cases the models interpreted from each method are in good agreement. However, there are occasions when the models present systematic differences that cannot be easily explained. This talk illustrates such a case using data acquired over the Olympic Dam polymetallic deposit. The apparent contradiction is shown to be resolved by the use of joint inversion software that allows for electrical anisotropy.

Peter's biography indicated that he had experience on 5 of the continents. I wondered which of the 7 continents he had not worked on. A quick web search indicated that opinion was in fact divided on whether there were 5, 6 or 7 continents, let alone what their boundaries are. Non-uniqueness is not restricted to geophysics.

As with the previous presentation, Peter demonstrated the complexity of the real world (e.g. anisotropy in electrical conductivity) and how the assumptions in 'standard' modelling codes might gloss over the complexities leading to wildly erroneous results. RL

Two-dimensional joint inversion of ZTEM and MT plane-wave EM data for near surface applications

Keith Fisk, Geotech Airborne

ZTEM (Lo and Zang, 2008) is an airborne electromagnetic (EM) geophysical technique developed from AFMAG (Ward, 1959; Labson et al., 1985) where naturally propagated EM fields originating with regional and global lightning discharges (sferics) are measured as a means of inferring subsurface electrical resistivity structure. A helicopter-borne coil platform (bird) measuring the vertical component of magnetic (H) field variations along a flown profile is referenced to a pair of horizontal coils at a fixed location on the ground in order to estimate a tensor H-field transfer function.

The ZTEM method is distinct from the traditional magnetotelluric (MT) method in that the electric fields are not considered because of the technological challenge of measuring E-fields in the dielectric air medium. This can lend some non-uniqueness to ZTEM interpretation because a range of conductivity structures in the earth depending upon an assumed average or background earth resistivity model can fit ZTEM data to within tolerance. MT data do not suffer this particular problem, but they are cumbersome to acquire in their need for land-based transport often in near-roadless areas and for laying out and digging in E-field bipole sensors. The complementary nature of ZTEM and MT logistics and resolution has motivated development of schemes to acquire appropriate amounts of each data type in a single survey and to produce an earth image through joint inversion. In particular, consideration is given to surveys where only sparse MT soundings are needed to drastically reduce the non-uniqueness associated with background uncertainty while straining logistics minimally.

Algorithm ZTMT2DIV is a generalization from previous code AV2Dtopo (Legault et al., 2012) that inverted ZTEM and AirMt data allowing topographic variations and a variable bird height. ZTMT2DIV algorithm makes use of the public domain finite element forward problem and inversion parameter sensitivities using reciprocity developed at the University of Utah (Wannamaker et al., 1987; DeLugao and Wannamaker, 1996), together with the regularized Gauss-Newton non-linear parameter step estimate described by Tarantola (1987). The performance of two-dimensional (2-D) joint ZTEM/MT inversion by ZTMT2DIV is tested using synthetic brick structures below a hill and valley model, similar to AVERT2D-topo. Subsequently, separate and joint inversion of coincident ZTEM and Titan dense array MT data over the Johnston Lake district, Saskatchewan, are performed. A result of this effort is that only very few (e.g. three) MT stations may be needed to correct for background resistivity effects in a ZTEM survey provided the MT sites are appropriately spaced.

Keith presented another example of having multiple data types integrated within a modelling and inversion application. In this instance, ZTEM and MT data were inverted for a single rock property (i.e. electrical conductivity).

There was enough overlap in the rock volumes sampled by the observations that we could gain confidence in the calibration of both methods through the consistency of the predictions for both data sets from a single model.

I admired Keith's deft sidestep for a tricky question from the audience – 'That is a great question that deserves a great answer. You can look for this in the slide notes, but if it isn't there, I can put you in touch with someone who can give you an answer.' RL

SESSION 3 CASE STUDIES 2 – GEOLOGICALLY CONSTRAINED INVERSIONS

Inversion of SkyTEM data over an ultramafic hosted Ni-Cu deposit in Greenland

John Joseph, Consultant

The Maniitsoq nickel-copper-PGE license block in Greenland hosts numerous high-grade nickel-copper sulphide occurrences. North American Nickels Inc (NAN), a British Colombia based company obtained the exploration license of this block and utilized the traditional prospecting methods, modern ground and airborne geophysical techniques for delineating the target areas to be drilled. As a part of the geophysical exploration a large portion of the licence block was flown with a fixed wing TEM system in early 1990. The extremely rugged terrain and the mandated higher ground clearance severely hindered the ability of the survey to see prospective EM. NAN has further reviewed these data and concluded that nickel-copper bodies missed by the above survey might well be detected by modern helicopter-borne TEM systems such as SkyTEM.

Based on the compilation of historical exploration results, two blocks of ground were selected for helicopter-borne EM and magnetic survey using SkyTEM-304 system. Blocks A and B together covered 375 km2 and included the largest norite intrusions and most significant nickel occurrences in the larger licence block. The survey was flown with a nominal spacing of 200 metres. The line spacing was reduced to 100 metres when potentially significant conductors were detected. The EM data were processed and inverted using both SELMA based code and laterally constrained inversion scheme called Aarhus workbench, and detected significant EM anomalies which were not detected by previous geophysical surveys. It was observed that many of the prospective intrusions have a significant component of remnant magnetism giving them a distinctive magnetic signature. Mapping out the distribution of this signature suggests that there may be considerably more prospective noritic rock in this area than is exposed on surface. A detailed discussion of the survey, data processing, inversion and drilling results will be presented.

John opened with a confession – he wasn't presenting a constrained inversion despite being the first speaker in the constrained inversion session!

During John's talk, I was reminded of a quote from Terry Lee … 'If you have seen one TEM decay, you've seen them all.' John showed us several TEM decays, and they certainly did all look the same. This was an excellent demonstration of just how useful modelling and inversion has been to extract the information that is present in EM data. EM has been a similar modelling and inversion success story to that of resistivity/IP, MT and magnetisation inversion in the sense that the model attributes are not always readily apparent from an inspection of the data. RL

Ways to integrate inversion in your interpretation

Tim Chalke, Mira Geoscience

The role of geophysics is necessarily evolving as modern exploration addresses the challenge of finding significant new deposits at depth, under cover, or in complex brownfields settings. This exploration activity can be driven by a fundamental understanding of mineralisation processes and the associated ore system signatures. This is therefore a step away from recognising anomalies in 'data space' but rather an interpretation in model space where the data informs components of this ore system signature. The aim of geophysical modelling can be to interpret the rock volume in terms of geometry, structure and rock properties associated with these components.

The interpretation of geophysical data can therefore be focused on informing geological objectives of understanding. This is done through interpreting how geophysical signatures relate to geology, and the geological meaning of rock properties. Interpretation of structure and geology leads to the modelling of key geological domains in 3D, attributed with best estimate rock properties. Inversion and forward modelling are utilised for quantitative reconciliation of geophysical data with the initial model followed adjustment of boundaries and physical properties where appropriate. The result is a model which honours the geophysical data, and which may be directly integrated with other multi-disciplinary data in 3D for exploration based around interpreted ore system signatures.

Happy birthday to Tim! What a birthday treat – to come along today to participate in this wonderful forum.

The day would not have been complete without a decent mention of the Common Earth Model concept that advocates for integration of model characteristics derived from multiple data types into a sub-surface mapping product to which different criteria can be applied to generate targets for different applications.

Another timely reminder from Tim was that so much more can be done than to just perform an unconstrained (default-setting) inversion. Yes, he recommended that we still do an inversion of this type, but he urged us to go further with input from rock properties and other forms of prior information.

When providing a second plug for the RPDB, Tim expressed the view that there are still issues with the reconciliation of rock property measurements with geophysical modelling results. RL

FALCON AGG inversion to constrain 3D geological models in the Glyde Sub-Basin, Northern Territory

Fabio Vergara, CGG

A high resolution FALCON® airborne gravity gradiometer (AGG) and magnetic survey was flown by CGG Airborne over the Glyde Sub-basin in the Northern Territory. Aim of the survey was the identification of the structural setting of the area to support Armour Energy's conventional and unconventional hydrocarbon exploration efforts.

A structural interpretation of the survey area was completed integrating the new AGG and magnetic data with historical geophysical information, regional and local geology (including two wells), remote sensing data and scientific papers. Advanced data processing was applied to improve the interpretation of the AGG data: pseudo-depth slices, to better understand the density variations at depth (Spector and Grant, 1970), and Shape Index, to define the geometry of the equipotential surface of the gravity field (Cevallos et al., 2013). The integrated interpretation was combined with 2.5D modelling on cross section and depth to magnetic basement to build a 3D Earth Model of the survey area. The 30 × 40 × 5 km volume was discretised into a voxel with 200 × 200 × 100 m cell size. The model was iteratively refined using homogeneous and heterogeneous 3D gravity gradient inversion (VPmg) to minimise misfit between calculated and observed data.

The interpretation and 3D modelling workflow applied in the Glyde Sub-basin project represents a solid approach to integrate available geological and geophysical data in a comprehensive 3D interpretation. 3D inversions proved valuable to refine the final model and as a quantitative tool to assess model reliability.

When integrated with a solid geological understanding, 3D inversions represent an additional tool for the geologists and the geophysicist to aid interpretation and improve 3D geological models.

Following on well from the previous talk, Fabio reminded us of the (never-ending) iterative nature of the Common Earth Model generation process. Around, around, around the loop we go – put forward an hypothesis, test it for compatibility with various observations, make adjustments to the hypothesis to improve the likelihood of this reflecting the world we live in, re-test the model, etc. RL

Use of geostatitically-constrained potential field inversion and downhole drilling to predict distribution of sulphide and uranium mineralisation

Matthew Zengerer, Intrepid Geophysics

This talk examines methods for generating geostatistically plausible 3D property values from downhole drilling logs, and how these property models can be used to both refine geological understanding and inform 3D property and lithology stochastic inversions. Examples are shown from a Copper deposit in the Northern Territory and a Uranium deposit in South Australia. Significance of the findings from forward modelling and inversion, as well as implications for exploration and inversion processes, are examined.

Matt drew our attention to many of the issues – a complete herd of elephants-in-the-room – that many of us would prefer to ignore …

- sparse data,
- an imperfect understanding of the Earth and its processes,
- simplified models,
- under-determined mathematical problems, and
- non-uniqueness.

He then provided examples of the use of a statistical/probabilistic/Bayesian approach to inversion. This approach didn't overcome the issues, but certainly made them apparent through the generation of multiple satisfactory models. RL

SESSION 4 NEW APPLICATIONS AND RECENT DEVELOPMENTS

Pit-scale geological modelling with EM and magnetics inversion

Chris Wijns, First Quantum Minerals

The economics of mining low-grade deposits is very dependent on having good resource models to inform the mine plan. Resource models involve more than grade distribution – they include factors such as rock hardness, volume of pre-strip material, and oxide vs hypogene ore and waste zones. In such cases, diverse data sets are needed to help construct the best geologically constrained resource model possible. High-resolution airborne EM and magnetic data over the Cobre Panama porphyry deposits help to define structures and domains inside the pit volumes. The EM data map the depth of saprolite, which informs pre-strip and oxide ore volumes. The broad mineralisation envelope is also reflected in the EM via the response to clay (sericite) alteration. This same alteration results in demagnetisation of the host rock. Both magnetic and EM data define lithological contacts, but there is inconsistent correspondence with structures mapped in surface quarries and streams.

Chris took us on a journey to a different place and scale. He reminded us that geophysical modelling and inversion can prove beneficial not just during exploration, but during resource modelling and mine planning as well.

He also stated something that we all knew – that 'geophysics is never wrong.' Very true, but you were a brave man, Chris, to say it out aloud. RL

Advances in cooperative inversions of seismic and MT data; and comments on grids and super-computing

Brett Harris and Andrew Pethick, Curtin University

Cooperative or Joint inversion of data from co-located seismic and magnetotelluric surveys has potential benefits. We investigate the circumstances under which cooperative inversion makes sense. We highlight a range of cooperative inversion workflows based on structural and or petrophysical relationships with the aid of synthetic and field examples. These type of inversion strategies need to be coupled with fast computing. In the modern 3D geophysical world, the speed at which inversion and forward modelling can be undertaken becomes paramount. Computation speed will impact the final result that can be achieved, in particular when multiple datasets are inverted in a joint/co-operative inversion workflows. We present methods to parallelise electromagnetic modelling and inversion code and provide two scenarios showing the potential benefits of parallel computing.

Brett had the challenge of trying to explain to us how two (apparently) unrelated quantities can be inverted in a combined or cooperative manner. Of course, they are both reflections on a single 'Common Earth' as Tim Chalke would have said.

Andrew gave a very quick tour of parallel processing terminology (e.g. 'embarrassingly parallel') before illustrating how we can now take advantage of grid/cloud/remote/supercomputing to expedite processing. RL

Meanwhile, at Geoscience Australia ... modelling and inversion related activities

Richard Lane, Geoscience Australia

Geoscience Australia is involved in geophysical modeling and inversion as a supplier of fundamental data, as an active practitioner, and for a certain group of clients, as a supplier of technical advice, and a supplier of computing services. The organisation is the custodian of national datasets that are often utilised for modelling, for example: gravity, magnetics, rock properties, surface topography, satellite imagery, and surface geology. In recent years, there has been an expansion of this role. Seismic reflection and magnetotelluric data acquired along traverses that cross key crustal features are made available to the public. A number of large regional AEM surveys have been flown, and the processed and modeled data are again made available to the public.

Modelling of geophysical data is carried out internally in support of groundwater, geohazard, petroleum, and minerals applications. Attendees at this forum would be most familiar with the work that is done for petroleum exploration via studies of frontier basins and the provision of supporting information for acerage release areas. In the minerals exploration arena, Geoscience Australia is focused on the UNCOVER agenda. The goal of this initiative is to achieve a step change in knowledge and methodologies in Earth Sciences that are relevant to mineral exploration beneath the cover. This change will be achieved through the four themes of the initiative: Characterising Australia's cover; Investigating Australia's lithospheric architecture; Resolving the 4D geodynamic and metallogenic evolution of Australia; and Characterising and detecting distal footprints of mineralisation.

Modelling of geophysical data is a key part of each of these themes, principally involving gravity, magnetic, AEM, MT, seismic reflection, seismic refraction, teleseismic, and thermal data.

Specific aspects of recent modelling-related work at Geoscience Australia that will be discussed in more detail include: regional gravity and magnetic modeling, AEM modeling, MT modeling, high performance computing, The Virtual Geophysics Laboratory, and the development and deployment of a second-generation Australian National Rock Properties Database.

How would you react to the challenge of performing gravity and magnetic data inversions to produce a model with 80 x 80 x 10 m cells from the surface to a depth of several kilometres, seamlessly across the entire continent?

After allowing the attendees to either pick themselves up off the floor or to stop laughing, Richard set out some of the initiatives that are underway at Geoscience Australia (GA) in geophysical modelling and inversion that would allow this goal to be met. It shall be exciting to follow the progress as GA marches towards this objective. RL

Student Events at ASEG–PESA 2015

The ASEG is organising two student events to be held in conjunction with the upcoming ASEG–PESA 2015 conference. One event is targeting high school students and the other is targeting university students (both undergraduate and post graduate). It is also planned to hold a 'Geophysics for Teachers' workshop on Sunday 15 February.

The High School Student Day will be held on Tuesday 17 February 2015 between 9:30 am and 2:30 pm at the Perth Exhibition and Conference Centre.

In summary:

- 50 free places are being offered for high school students and an accompanying teacher, kindly sponsored by Woodside and ASEG–PESA 2015.
- Invitations are being sent to 300 schools and 500 science teachers from across Western Australia asking them to nominate 5–10 students from each school to attend the day.
- The event aims to encourage Year 11 and 12 students to consider a career in geoscience.
- The day will consist of a talk by Koya Suto 'Hitchhikers Guide to Geophysics', followed by a series of hands on activities/experiments (magnetic survey, ground penetrating radar, micro-seismic).
- There will be a tour of the exhibition space.
- There will also be a short talk about education pathways into geoscience.
- More information can be found at http://www.conference.aseg.org.au/registration-social-functions/high-school-student-day.html

The University Student Social Function and EAGE GeoQuiz will be held on Tuesday 17 February 2015 between 6:00 pm–9:00 pm at Bob's Bar, The Print Hall, Brookfield Place, 25 St Georges Tce, Perth.

In summary:

- This is a free event for undergraduate and postgraduate students with 75 places available.
- Food and drinks will be provided.
- EAGE have kindly offered to put on their EAGE GeoQuiz and have donated a first prize for the winning team to attend the 77th EAGE Conference & Exhibition in Madrid, Spain 1–4 June 2015. The prize includes airfares, accommodation and entry to the conference. This is a great prize and the ASEG is very grateful to the EAGE for their generosity.
- To participate in the EAGE GeoQuiz, students must register their team of 2 or 3 at the EAGE booth at the conference hall.
- The event is kindly sponsored by ASEG–PESA 2015.

Some additional student oriented activities for university students are planned with full details to follow on the ASEG–PESA website http://www.conference.aseg.org.au/

These will include:

- An opportunity for university students to participate in a mock job interview
- An opportunity for interested students to partner up with an ASEG member who will spend a few hours introducing them to industry professionals and mentoring them on their career path
- A session where students can listen to some short talks on academic and industry career paths and have the opportunity to ask questions.

For more information about any of these events please contact Adrian Noetzli adrian.noetzli@gpxsurveys.com.au

Geophysical adventures: the Geomagnetic Repeat Station Survey 2014

Bill Jones, Andrew Lewis and Liejun Wang

Email: geomag@ga.gov.au
Web page: http://www.ga.gov.au/scientific-topics/positioning-navigation/geomagnetism

Geoscience Australia (GA) operates a network of ten permanent geomagnetic observatories in the Australian region and Australian Antarctic Territory. To supplement the geomagnetic secular variation data collected at these observatories, a network of fifteen geomagnetic repeat stations is also maintained in Australia and the south-west Pacific. These repeat stations are occupied once every three to five years to collect secular variation data for use in modelling the regional magnetic field.

New Caledonian repeat station.

Close up of a Norfolk Island repeat station.

The data collected from the observatory and repeat station network are also used by the wider community, including government agencies such as the Bureau of Meteorology's space weather service IPS to aid in space weather monitoring, and researchers studying the Earth and near Earth environment from the core through the crust and into the atmosphere, magnetosphere and space. Magnetic time-series data from the network are available as an alternate source for magnetic base station data for the mineral exploration and drilling industry. Regional and global field models derived from the data are useful for navigation and magnetic direction finding.

At each of the repeat station sites a magnetic variometer system is deployed over a three to four day period. The variometer system consists of a 3 axis fluxgate magnetometer and a total-field magnetometer. These instruments record the magnetic field constantly for the duration of the occupation. During the daylight hours absolute observations are carried out to calibrate the variometer system to geomagnetic observatory standards. These calibrations are conducted using a fluxgate magnetometer mounted on a non-magnetic theodolite and a proton precession magnetometer. The repeat stations are generally located at airports where the magnetic environment remains stable over the medium to long term so the repeat stations remain free from magnetic contamination.

During the first half of 2014 four repeat stations were occupied by geophysicists from GA. These stations were located in Tontouta (New Caledonia), Norfolk Island, Kavieng (PNG) and Vanimo (PNG). Mainland Australian stations were occupied over the previous two years.

Bill and Andrew got the first gig in New Caledonia. The repeat station in New Caledonia is located within the boundary of La Tontouta International airport which is approximately 40 km to the north of the capital Noumea. To gain entry each day we had to visit the local Gendarmerie and hand over our passports to collect a gate pass. Considering that we don't speak any meaningful French, these officers were always friendly whenever we visited. The weather was very

Liejun Wang making observations at a Kavieng repeat station.

pleasant, if a bit windy, but when is an airport not windy?! For the sake of convenience we stayed close to the airport rather than make an 80 km round trip each day. We were the last guests at the hotel before it shut down, however we don't think that we were the cause. Near the end of the occupation the variometer site also had a visit from a large excavator, which was removing trees from a drain. Needless to say, this visit resulted in some contamination which needed removing before processing.

Bill Jones making observations at a Vanimo repeat station.

The next repeat station was on Norfolk Island , which we flew to from New Caledonia via Australia.

Unfortunately the flight from Sydney only had one seat available, so Bill flew ahead to start setting up the variometer whilst Andrew had an overnight stay in Brisbane and arrived the next day. When Bill woke up on the third day he was not feeling very well and, after a quick trip to the doctor, he was diagnosed with Chicken Pox. This left Andrew to complete the occupation by himself as Bill was restricted to bed rest. To add to the discomfort for Andrew, a tropical cyclone passed to the east of the island which made things very windy and very wet. We then returned to Australia where Bill spent the next week in self-imposed isolation.

Six weeks later the Papua New Guinean leg of the survey was undertaken by Bill and Liejun. The PNG stations are located at the airports in Kavieng (New Ireland) and Vanimo (Sandaun Province). We spent one night in Port Moresby before heading off to New Ireland. We set off to the airport to catch the flight to Kavieng first thing in the morning. At the check-in counter Bill was able to lodge his share of the luggage but Liejun was left standing at the counter for quite some time. Eventually he was told that a seat was available for him but there was no room for his luggage. So, once again, the team had to split up, with Bill heading off with the variometer system. Once in Kavieng a location within the perimeter fence of the airport was found for the variometer system. As this spot was located on the airfield there was, of course, no easy access to mains power. So, to power the site, we needed to purchase two car batteries, with these being swapped in and out once a day. The next day the flight arrived with Liejun and the rest of the gear. A search for the repeat stations then began, but with several years' worth of vegetation laying on top this naturally took several hours to sort out. With the help of the airport staff we eventually found the first of the stations. Using this station, we were then able to set up the theodolite. Then, with lots of hand waving, the second station located on the opposite side of the runway was also found. This was the end of our sunny weather at Kavieng, as from that point on it proceeded to rain whenever we stepped out of the car.

Vanimo repeat station with airport worker visiting.

The next station was at Vanimo airport, where we had lots of lovely sunny but humid weather. In Vanimo the airport grounds are unfenced so a secure location for the variometer needed to be found. The airport safety officer came to the rescue when he allowed us to use his garden. At this site we also had access to the mains to supply power for the instruments, however, we were soon to discover that the power supply in Vanimo is not very reliable. Power outages lasting several hours occurred each day during our visit. Eventually a truck battery was purchased and connected via a battery charger to the mains to create a make shift UPS. During the day, whilst collecting the absolute observations with the theodolite/magnetometer system, we often played host to curious locals who were using the airport as a short cut into town. So, after five days of data collection we were finally confident that we had collected enough data and packed up to return to Port Moresby. At the airport another power outage had occurred so Bill had to 'duck back' into town to find a bank so that he could withdraw enough cash to pay for the excess baggage. Another quick overnight stay in Port Moresby and we then started leap frogging back to Canberra via Cairns and Sydney.

All the data that have been collected over the last five years from these repeat station surveys will be combined with the data from the permanent geomagnetic observatories. These data will form the basis for modelling the 2015 AGRF.

Vale Alan Appleton (1934–2014)

Alan Appleton joined the South Australian public service in 1971 and was a Technical Assistant with the Geophysics Section until 1990 in the Department of Mines. He was then transferred to the Mineral Exploration Division within the South Australian Department of Mines and Energy until he retired in 2005. He assisted with the organisation of many events, field trips and special occasions for staff throughout the agency. Alan was always able to procure required items for projects, events and conferences and was happy to help with anything, sometimes appearing like a genie at one's side [Editor's note: I can also vouch for Alan's uncanny abilities in this regard!]. Alan was a key contact for explosives which was a critical issue for seismic surveys that were undertaken by the department up until 1990. For many years he was also an OH&S representative for the Geophysics Section.

Alan was rarely without his hat which featured on his coffin at his funeral service. He was conspicuous by the row of pens in his pocket and various lanyards and other accoutrements he carried, indicating that he was ready, willing, able and prepared for action. Alan was always well presented, unfortunately the same could not be said about his office! He was one of the true characters of the agency.

Alan was a strong supporter of the Australian Society of Exploration Geophysicists (ASEG). He joined in 1977 virtually at the start of the South Australian branch of the society. Over many years he was a part of many meetings, events and conferences, arranging transport and procurement of a wide range of necessary items. He was also on the state branch committee for many years. His support to the society was recognized in 2001 when he was awarded the ASEG Service Certificate. He continued his association with the society after retirement till 2008.

Alan is survived by his wife, Pat, sons Chris, Philip and Duncan, seven grandchildren and three great grandchildren. On behalf of his former colleagues in the Department of Mines, subsequent named agencies and the ASEG, he will be remembered as a kind and gentle soul who was always willing to give a hand.

Dave Cockshell
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ASEG-PESA 2015

Geophysics and Geology together for Discovery

24th International Geophysical Conference and Exhibition
15 – 18 February 2015 Perth, Western Australia

A well rounded and exciting list of abstracts was received in October for the 24th International Geophysical Conference and Exhibition, at the Perth Convention and Exhibition Centre, Western Australia. These were in keeping with the theme for 2015: 'Geophysics and Geology together for Discovery' – invoking the fundamental tenets behind our shared efforts to effectively and safely discover the natural resources needed for future generations. National and international key-note speakers have been secured as a catalyst to ensure dynamic and relevant technical sessions. The exciting line up of keynote speakers includes:

- Minerals: Eric Anderson, Peter Betts, Richard Hillis, Scott Halley, Jon Hronsky, David Isles, Mark Jessel, Richard Lane, Gavin Selfe, John Vann, Ken Witherly
- Near-Surface: Alireza Malehmir, Laura Valentina Socco, Rosemary Knight, Fiona Hook
- Petroleum: Tariq Alkhalifah, Per Avseth, Dennis Cooke, Peter Duncan, Michael Glinsky, Felix Herrmann, Ian Jones, Simon Lang, Nick Moldoveanu, Henry Posamentier

Registrants are encouraged to look at the workshops/courses organised over the weekend leading up to the conference. These have been released and include:

- Explorational Rock Physics and Seismic Reservoir Prediction.
- An Introduction to Velocity Model Building.
- Geophysical Downhole Logging.
- AEM processing and modelling fundamentals.
- Full Waveform Inversion: Where are the Anisotropic Parameters Hiding?
- Geology for Mineral Exploration Geophysicists.
- AEM processing and modelling fundamentals.
- Geophysical signatures of mineral systems; more than bumps.
- Modern 3D-IP surveying. Practical techniques and short cuts. Benefits, limitations and pitfalls.

Spaces are limited so registrants are encouraged to reserve a spot early. The committee has worked hard to ensure that all the sessions are informative and inspiring and the ASEG-PESA team are pleased to offer complementary membership to either society for non-members along with a discount for current Members. See you in February!

ASEG-PESA 2015 Conference Organising Committee
www.conference.aseg.org.au

UNCOVER – Progress in the vision for exploration geosciences and mineral discovery in Australia

This month *Preview* has published online sixty presentations from the UNCOVER Summit and post-Summit Workshop, held in Adelaide between 31 March and 2 April. A list of these presentations is appended to this summary of progress in the UNCOVER initiative.

The UNCOVER initiative in our national mineral exploration endeavours, formulated under the aegis of the Australian Academy of Science (see *Preview* February 2014, p. 14), aims to build a strategy that will find new Tier 1 mineral deposits under the 80% of Australia where favourable geology lies below regolith or other barren cover. This outcome will be facilitated by increasing the national conversation between industry, research providers (academia and CSIRO), government surveys, and policy-development arms of government, in order to enhance the communication, direction and focus of new technologies, models and exploration programs.

Last April the UNCOVER Executive Committee welcomed The Honourable Martin Ferguson AM (a past Minister for Resources and Energy in the Rudd–Gillard governments) as Patron. In this role we believe Mr Ferguson will greatly assist in our liaison with policy-makers in government.

The UNCOVER initiative has progressed on four fronts this year. Firstly, publication of the Summit presentations by the ASEG, at request of the UNCOVER Executive, meets the need for archiving the Summit material in a citeable, discoverable and downloadable form. We have achieved this by use of the *Preview* format, which ensures that CSIRO Publishing will host this resource as a permanent archive, accessible through standard databases and web searches. Two summary documents, which appear at the head of the list of presentations, are vital reading for all explorationists; the first summarises strategy and emerging geosciences priorities as identified in the Summit, while the second summarises the findings of the post-Summit cover thickness mapping workshop. The synergies of airborne gravity gradiometry with airborne EM (AEM) for determining regolith thickness, and of both active and passive seismic methods with ground EM data are points well made in this review.

Secondly, an UNCOVER Geoscience Committee has been formed under chairmanship of Steve Beresford, Chief Geologist of First Quantum Minerals Ltd. One of the roles of the Geoscience Committee will be to identify and recommend endorsement of projects, in particular 'headline projects' which may become the focus of the UNCOVER initiative.

Thirdly, AMIRA International has launched a Road-Map initiative as part of Project *P1162: Unlocking Australia's Hidden Potential*, under the leadership of Robbie Rowe of NextGen Geological Pty Ltd. This initiative will provide an opportunity for industry to contribute to a blueprint for addressing the challenges and gaps in knowledge, technology capability together with an assessment of the research capacity (human resources and infrastructure) required to improve the exploration success rate in areas of post mineral cover. Further details are at http://www.amira.com.au/web/documents/newsletter/amiranewsletter37.pdf. AMIRA advises that Project *P1162* has now received the necessary threshold funding and has commenced with an impressive total of 34 companies and government agencies signed up.

Fourthly, Geoscience Australia and the Australian state and Northern Territory geological surveys have embraced the UNCOVER initiative as a major part of their support for the mineral exploration industry. Richard Blewett, Group Leader Mineral Systems for Geoscience Australia, gives an overview of current efforts, beginning with studies in the Stavely area under Murray Basin cover of western Victoria and continuing with studies in the Thomson Orogen of northern NSW, Queensland and Northern Territory. These projects have the involvement of a number of geoscientists within Geoscience Australia, plus additional input from state surveys and universities. See more at http://www.ga.gov.au/news-events/news/latest-news/uncover-unlocking-australias-hidden-mineral-potential.

Michael Asten
Australian Geoscience Council Representative on the UNCOVER Executive
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Searching the deep earth

A vision for exploration geosciences in Australia

Presentations and summaries from the UNCOVER Summit and UNCOVER Workshop, Adelaide Convention Centre 31 March to 2 April 2014. Presentations should be referenced by author, title, *Preview* **172**, The Australian Society of Exploration Geophysicists, October 2014.

SUMMARY DOCUMENTS

- UNCOVER (2014), UNCOVER Summit: unfolding the vision for exploration Geoscience towards a brighter mining future in Australia, Summit 2014 and Next Steps
- Geoscience Australia (2014), UNCOVER: cover-thickness mapping technical workshop summary and outcomes

PRESENTATIONS

Monday 31 March 2014

Session 1

- Paul Heithersay (DMITRE) What is the future for government geoscience initiatives in Australia?
- Jonathan Law (CSIRO) Minerals down under flagship
- Stephen McIntosh (Rio Tinto) Leveraging investment in the Earth sciences to meet future mineral discovery challenges
- Chris Pigram (Geoscience Australia) Making Australia competitive: undercover mineral discovery
- Sue O'Reilley (Macquarie University) A national trajectory for geoscience research in Australia and some historical perspectives towards UNCOVER

Session 2

- Charles Funk (Newcrest) Industry requirements for undercover exploration
- Joe Cucuzza (AMIRA) Minerals industry challenges: unlocking Australia's potential through collaboration
- Richard Schodde (Minex Consulting) Challenges and opportunities for under-cover exploration in Australia
- John Holliday (Independent) What's needed, and what's not

Session 3

- James Cleverley (CSIRO) Innovation to support the UNCOVER business
- Steve Hill (DMITRE) The cover: love thy enemy
- Ravi Anand (CSIRO) Transported cover: friend not an enemy

Quickfire session 1 – geological surveys

- Andy Barnicoat (Geoscience Australia) Unlocking Australia's hidden mineral resource potential: GA's national projects
- Steve Hill and Miles Davies (GSQ) Mineral system 'haystacks' in South Australia's deep cover exploration frontiers: from impediment comes opportunity
- Paul McDonald (GSV) Victoria's Earth resources under cover
- Jamie Robinson (GS NSW) Constraining thickness of transported cover and basement geology: tasmanides undercover in NSW
- Vladimir Lisitsin (GSQ) Intrusion-related mineral systems of north-east Queensland
- Vladimir Lisitsin (GSQ) Metallogenic analysis: defining and mapping mineral systems
- Adrian Fabris (GS SA) Mapping mineral systems under cover; using drill rigs instead of geological hammers
- Tania Dhu (NT GS) Uncovering the Greater McArthur Basin, Northern Territory
- (a) Dr Ian Tyler (GS WA) The Geological Survey of Western Australia: what does a state geological survey do in 2014?
  (b) Dr Ian Tyler (GS WA) Western Australia's Exploration Incentive Scheme
- Dr Mark Duffett (MRT) The Tasmanian UNCOVER perspective

Tuesday 1 April 2014

Session 4

- Richard Blewett (Geoscience Australia) Australia's lithospheric architecture: imaging for under cover mineral discovery
- Bill Griffin (Macquarie University) Archean SCLM: what do we (think we) know?
- Mark Jessell (UWA-CET) Next generation 3D modelling and inversion: what you don't know can help you

Session 5

- Steve Beresford (First Quantum) Theory of constraints applied to mineral systems
- Chris Kirkland (GSWA) Isotope geology through space and time: a tool for understanding crustal evolution
- John Miller (UWA-CET) Resolving the 4D geodynamic and metallogenic evolution of (west) Australia: towards better prediction

Session 6

- Peter Winterburn (UBC) Sizing up the footprint: concepts in regional scale undercover geochemistry
- Peter Bewick (Encounter Resources) Footprints in the Great Sandy Desert
- Matt Greenwood (GSQ) Regional 3D mineral potential modelling using geology and geophysics
- Bruce Gemmell (CODES) Metal dispersion around porphyry Cu-Mo-Au deposits: implications for fluid flow and exploration
- Shaun Barker (University of Waikato) Teaching and old dog new tricks: stable isotopes in mineral exploration

Quickfire session 2 – innovations in technology

- Mathew Murphy (Bluestem P/L) Trace element chemistry of sulphides and its potential as an indicator in gold deposit exploration
- Kim Frankcombe (ExploreGeo) Chasing Volkswagons at 2 km with IP
- Lynn Pryer, Timothy Debacker, Karen Connors and Jane Blevin (FrogTech) OZSEEBASE™: basement uncovered

- Elena Belousova, William Griffin, Norman Pearson, Suzanne O'Reilly and Yoann Greau (GEMOC, Macquarie Univ) TerraneChron®: remote sensing with detrital samples
- Don Pridmore & Greg Turner (HiSeis Pty Ltd) Seismic and mineral exploration under cover? Time for a new relationship
- Graham Heinson (Univ Adelaide) Deep imaging and monitoring with magnetotellurics
- Ivan Belouov, Sebastien Meffre, Dan Gregory, Jeffrey Steadman and Ross Large (CODES Univ Tas) Pyrite geochemistry as a proven vector to ore
- Zhen-Xiang Li (Curtin University) Greenfield identification: big picture matters
- Helen Williams (MMG) Overcoming ground disturbance issues with alternative electrical imaging techniques
- Nick Smith (OZ Minerals) Passive seismic for mineral exploration under cover
- Theo Aravanis (Rio Tinto) The regolith – a proposal for regional airborne EM surveys to supplement gravity gradiometer surveys
- Dave Giles (Univ Adelaide) Mineral Systems Drilling – DET CRC's strategy to UNCOVER deep prospectivity

Wednesday 2 April 2014

Session 7

- Joe Cucuzza (AMIRA) What exploration companies want from UNCOVER
- Richard Hillis (DETCRC) Round table summary and grand challenge

Session 8 – The need for a Geoscience Committee and a Communications Committee

- Michael Asten (Monash University) UNCOVER stakeholders
- Theo Aravanis (Rio Tinto) Priorities in UNCOVER initiatives

UNCOVER: cover-thickness technical workshop

Aim of the workshop

Develop practical solutions for mineral explorers to determine the depth of cover at the tenement scale by identifying the optimal trade-off between accuracy and data acquisition costs for the range of Australian cover materials.

SUMMARY DOCUMENT

- Geoscience Australia (2014), UNCOVER: cover-thickness mapping technical workshop summary and outcomes

PRESENTATIONS

- Andy Barnicoat (Geoscience Australia) Introduction
- Steve Hill (Geological Survey SA) Nature of Australian Regolith
- John Wilford (Geoscience Australia) Remote sensing and radiometric
- Clive Foss (CSIRO) Magnetics
- Des FitzGerald (Intrepid Geophysics) Gravity
- Kim Frankcombe (ExploreGeo) Ground electric (IP/resistivity)
- Graham Heinson (University of Adelaide) Magnetotellurics
- Jim Macnae (RMIT University) Airborne electromagnetic
- Michael Asten (Monash University) Passive shallow seismic
- Milovan Urosevic (Curtin University) Active source shallow seismic

Cecil Green Enterprise Award for DownUnder GeoSolutions

The Society of Exploration Geophysicists (SEG) recently announced that Perth based DownUnder GeoSolutions will receive one of the industry's most prestigious awards, the Cecil Green Enterprise Award, at the Honours and Awards Ceremony, part of the SEG's International Exposition and 84th Annual Meeting in Denver, 26–31 October.

The Cecil Green Enterprise Award (http://wiki.seg.org/wiki/Cecil_Green_Enterprise_Award) was established by the SEG to recognise the importance of an individual enterprise to the economic vitality of the exploration industry and is conferred from time to time on persons who, in the unanimous opinion of the SEG Honours and Awards Committee and the Executive Committee, have demonstrated courage, ingenuity, and achievement while risking their own resources and future in developing a product, service, organisation, or activity which is recognised as a distinct and worthy contribution to the industry. Previous award recipients include that notable Australian geophysicist, Pat Cunneen.

The SEG have recognised that Matt Lamont and Troy Thompson, founders of DownUnder GeoSolutions, embody the spirit of the Cecil Green Enterprise Award in a story of personal risk and enterprise. They founded DownUnder GeoSolutions in 2003 in a shed in Matt's yard in Perth, Australia. They developed and wrote their own software, so originally they had very limited offerings (AVO and inversion software and services) while they worked on development. By 2008, the company had grown to 45 people, and 92% of the shares were held by employees. That year they won their first major Seismic Processing project covering 1500 km^2 of data, and commercialised the 'DUG Insight' suite of software. DownUnder now has offices around the world, employs about 200 people, and is a supplier of interpretation software and seismic data-processing services worldwide. All of this could not have been achieved without considerable personal financial risk and the incredible vision and determination of Matt and Troy.

In the biographical citation Norm Uren and Carlo Bevilacqua write that both Matt Lamont and Troy Thompson had distinguished academic careers as students in the Department of Exploration Geophysics at Curtin University in Western Australia. Matt won the competitive K. A. Richards APPEA Scholarship, an Australian Postgraduate Award, an Australian Cooperative Research Centre Scholarship, and the Australian Institute of Mining and Metallurgy Prize. He earned a bachelor of science degree with first-class honours and completed his PhD in 1998.

Matt Lamont

Troy won the Dean's Prize as the top student in the Faculty of Science whilst he was an undergraduate and was inducted as a member of the Golden Key National Honour Society. He won the AIP Most Outstanding Graduate Prize, the RioTinto/CRA Field-mapping Prize, and the Royal Society Science Medal. As a postgraduate student, he won the John Curtin Postgraduate Scholarship, BHP Billiton Research Scholarship, a Petroleum Exploration Society of Australia Scholarship, and a MERIWA Supplementary Scholarship. He completed his PhD in 2004, with Matt as one of his supervisors.

Troy Thompson

Both Matt and Troy published internationally and made international conference presentations while still students, with Matt's multiple-attenuation algorithm featured on the front page of *The Leading Edge* in January 1999. In his early career, Matt worked as a geophysicist with Phillips Petroleum, reservoir evaluation geologist with Woodside Offshore Petroleum, senior research geophysicist with Texseis (Houston), senior geophysicist with BHP Billiton in Perth, and technical leader with Seismic Imaging and Processing (Houston). Matt has always been research minded and served a very productive term as associate professor and chairman of the Curtin Reservoir Geophysics Consortium of industrial supporters for petroleum research. His strong participation ensured the industrial relevance of the research.

Matt's dream of starting his own enterprise became a reality in 2003 after he approached young, high-achieving Troy with his ideas of a small consultancy. Troy was up for the challenge. A small number of past colleagues who knew and had confidence in Matt and his vision provided a modest amount of start-up capital, and DownUnder GeoSolutions (DUGEO) was born. A small team was assembled, working from a shed (which they had to first build) in Matt's backyard in Perth, Western Australia.

In the early days, Troy headed up quantitative interpretation (QI), while Matt explored a gap he had identified in the market and focused on developing a processing and imaging tool kit for small-scale processing. DUGEO developed a unique QI workflow that attracted the attention of some local innovative oil companies, and in 2006, the first major discovery was made. This led to a string of successful discovery wells, and today, two field development projects are under way. Meanwhile, Matt developed a seismic-imaging tool kit, initially with the support of an Australian Commonwealth Government grant.

The company rapidly outgrew Matt's shed and moved to new offices in nearby Subiaco. It now has headquarters in West Perth, with seven other international offices. DUGEO's service offering has continued to expand to include illumination studies, seismic data processing, depth imaging, petrophysics, QI, geostatistical depth conversion, and multiclient studies.

With a strong R&D focus from day one, DUGEO developed its own interpretation software, called DUG Insight, allowing greater productivity and providing superior technical workflows to its internal service geophysicists. It was not long before clients started to request those tools for use themselves. DUG Insight is now the interpretation-software platform of choice in hundreds of companies worldwide. It is an interactive package, working from field tapes right through to QI.

Academic success is in no way a guarantee of success in business, but Matt and Troy's dedication, talent, determination, and plain hard work have taken DownUnder GeoSolutions from humble beginnings to the significant global company that it is today.

The Cecil Green Enterprise Award to DownUnder GeoSolutions is well deserved and the ASEG congratulates Matt and Troy!

Thinking global, acting local: the inaugural Victorian Petroleum Geoscience R&D Forum

On Wednesday 6 August the Victorian/Tasmanian branch of PESA held its inaugural Victorian Petroleum Geoscience R&D Forum, attracting over 40 participants and covering a wide range of current, local R&D initiatives over the course of the afternoon. Senior researchers in academia, government and private organisations, along with local postgraduate students were invited to present either 'progress reports' on their geology or geophysics research or 'discussion topics' related to efforts to promote R&D and industry collaboration.

The participant mix consisted of representatives from several local oil and gas companies, local ASEG members, consultants, service providers and academics. It was particularly encouraging to see many students attend and we would love to see some come back as presenters next year. In true 'forum' style, we witnessed a higher level of audience participation, then a typical PESA luncheon, which continued through to the PESA/ASEG/SPE social event that was held nearby and immediately afterwards.

Highlights/key learnings of the day included:

- The 'free-for-all' discussion and frank exchange of views on the state of geoscience R&D
- Similarity across some of the diverse topics via common integration techniques
- Painstaking field and lab work is still a key component of advancing our understanding of the subsurface
- Cross-disciplinary networking opportunities
- The provision of all presentations shown on the day to participants

The feedback provided on the day indicated a strong desire for us to run this event on a yearly basis, combined with more frequent communication on local R&D initiatives, perhaps using an internet forum approach. Ultimately we hope to encourage a greater level of R&D investment from industry and, in doing so, contribute to building a healthier local geoscience community.

The latter remark probably requires a little more explanation. We are essentially referring to a 'trickle-down' effect, whereby industry R&D investment ultimately improves the opportunities for students who may eventually become the next generation of resource finders. We can only speak for Victoria, but as the major resource companies have departed (or stayed and simply stopped investing locally) many senior industry figures feel that there has been a gradual decline in local geoscience opportunities and skills. This skills gap will almost certainly be amplified by the 'great crew change' occurring at present.

A collaborative approach akin to the AMIRA model (in the minerals sector) may be the way to engage small companies that currently dominate the local scene. An appealing side benefit is that companies involved would have early and quality access to fresh talent that soon will be so desperately needed. The costs of this may be quite low for individual companies, depending on the number of collaborators; the availability of matching government funding; and via R&D tax incentives.

We are actively seeking nominations for speakers for 2015, so please get in touch with your ideas as soon as possible. We are also looking for individuals from both PESA and ASEG to join a small subcommittee with the goal of establishing a range of sustainable initiatives related to enhancing local geoscience R&D.

Speakers	Talk titles
Prof Louis Moresi, Melb Uni	The dynamics of congested subduction zones: looking for new patterns in old convergent boundaries
Dr James Gunning, CSIRO	AVO inversion, fluids and facies: maximising the discrete Bayesian posterior
Dr Anne-Marie Tosolini, Melb Uni	Early Cretaceous palaeoenvironments of Eumeralla Formation, Otway Basin
Dr Joe Cucuzza, AMIRA	Collaboration in R&D: The minerals industry experience
Prof Mike Hall, Monash Uni	Riddles from the Rifts
Hamed Aghaei, Monash Uni	Upper Strzelecki Group stratigraphic reconstruction – a case study of coastal outcrops near Wonthaggi
Helen Gibson, Intrepid Geophysics	Innovations in potential fields modelling for greenfields exploration
Helen Sant, KPMG	R&D tax incentives
Prof Louis Moresi, Melb Uni	New basin genesis hub initiative (discussion)

Helen Gibson presenting to the inaugural Victorian Petroleum Geoscience R&D Forum.

Representatives from other state branches of PESA and ASEG are welcome to contact the authors for support in starting up their own local version of this event. The event was fully sponsored by KPMG, who are a leading provider of services to the industry in the area of R&D tax incentives.

Jarrod Dunne and James Karakatsanis
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Call for contributions to Mineral Exploration: Trends and Developments in 2014

A call has gone out for contributions to **Mineral Exploration: Trends and Developments in 2014** to be published in The Northern Miner, February/March, 2015. This annual review originated with the Geological Survey of Canada (GSC) over 50 years ago. In 2015, the review will be published by The Northern Miner as a supplement, in a magazine format, to be printed in time for the annual Prospectors & Developers Association Convention (PDAC) in March, in Toronto. The review is not only distributed to Northern Miner subscribers, but is also available to PDAC attendees and, ultimately, online.

The Canadian Exploration Geophysical Society (KEGS) is a 'patron' of the review, which is made possible by mining and exploration industry sponsors. The GSC also continues to play a contributing role in its production.

In 2015 the review will adopt the following headings:

- General Exploration and Corporate Highlights
- Airborne Geophysical Surveying
- Ground Survey Techniques (including drill hole methods)

The headings will cover the following topics:

- New geophysical (airborne, ground & borehole) data acquisition and processing techniques.
- New instrumentation developed during 2014 particularly that being (or about to be) offered for sale by instrument companies.
- New services offered by survey companies.

If you are interested in contributing to this review you should contact Patrick G. Killeen (pkilleen@xplornet.ca).

The deadline for contributions is 14 November 2014.

Ken Witherley
ken@condorconsult.com

The proposed Exploration Development Incentive scheme explained

Geoff Muers
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Associates tell me that sentiment for mineral exploration is the worst they have seen in 40 years. I struggle to think what life may have been like in 1974, aside from the trend of wearing knee-high white socks. I do remember that, after graduating from geology in the late 1990s, I wrote to every mining company in Australia, including all of the big names back then, BHP, RIO, North, WMC, Comalco, MIM, Newcrest, Homestake, Anglo and others. I had a pile of about 50 rejection letters, which I kept. I was out of work for at least six months until a small consultancy opportunity arose.

Unemployment amongst Australian geoscientists is now back to levels last seen in the late 1990s, it is above 15% and probably rising. Australia's share of global mineral exploration expenditure has fallen from over 20% in the 1990's to around 12%. Clearly some of the problems that the Australian Mining Industry has are of its own making, namely:

- Wage and cost inflation. Exploration staff used to work 2 or 3 weeks to get a week off. Not these days, with 7/7 rosters common. Inflation is not confined to the mining industry either, with Australia's minimum wage now one of the highest in the OECD.
- Productivity decline. A consequence of generous rosters and a decline in equipment productivity (down by 20% over the last 5 years).
- Excess in previous years. Drilling of prospects that had little chance of ever being economic, development of mines at the higher end of the cost curve.

Despite these problems Australia can still be considered the most prospective country for mineral resources in the world, as indicated by rate at which discoveries are made. On average ten new discoveries are made every year (Schodde 2013, see also Figure 1) and the bulk of those discoveries are being made by junior explorers. It is estimated, for example, that 86% of all discoveries in NSW in the last decade were made by juniors (Schodde 2014). However, financial resources available to the junior sector have dramatically declined in recent years. Drilling has slowed (see Figure 2) and some forecasters predict 50% of Australia's metalliferous mines may close within the next 15 years unless spending on exploration and pre-development returns to levels seen in the last 5 years or so.

In order to encourage expenditure on mineral exploration in Australia the Federal Government is proposing to introduce an Exploration Development Incentive (EDI) scheme. This scheme will enable tax credits to be passed on to investors in the junior mining sector. There is already deductibility and refunds for junior explorers through Research and Development (R&D) rebates, and state-based co-funding for drilling however, the individual investor can only offset their losses against other profits and capital gains. I suspect most investors in the sector are currently sitting on losses and, no doubt, many have given up any expectation of a return.

The Federal Government plans to trial the EDI scheme for three years, with a cap on exploration credits of A$25m in FY'15, rising to A$35m in FY'16 and A$40m for FY'17. It is currently uncertain whether companies will apply the credits to existing share capital, or only newly issued shares. Future capital raising (newly issued shares) should be preferred if the aim of the scheme is to attract new money for exploration. In the current environment, persuading new investors to put money into mineral explorers is like getting blood from a stone.

The scheme can only be used for companies exploring for minerals (not petroleum, gas or quarry materials) in Australia, and is not available to entities in production. As the scheme is designed to boost discovery rates, the incentive will not be applied to expenditure on scoping and feasibility studies (an incentive is definitely needed here, as many companies struggle to fund this stage), but will be applicable to geophysical data acquisition and analysis,

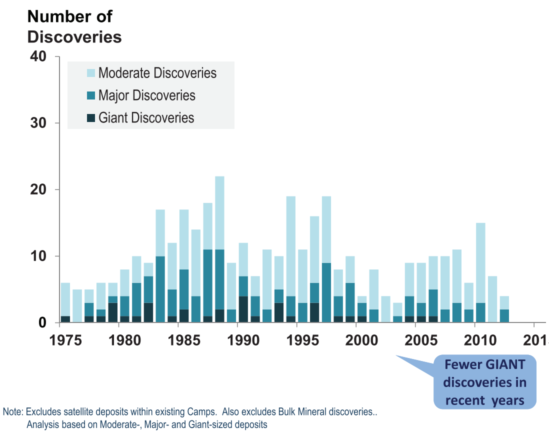

Figure 1. *Number of significant discoveries made (non-bulk discoveries Australia: 1975–2012). Source: Schodde, 2013.*

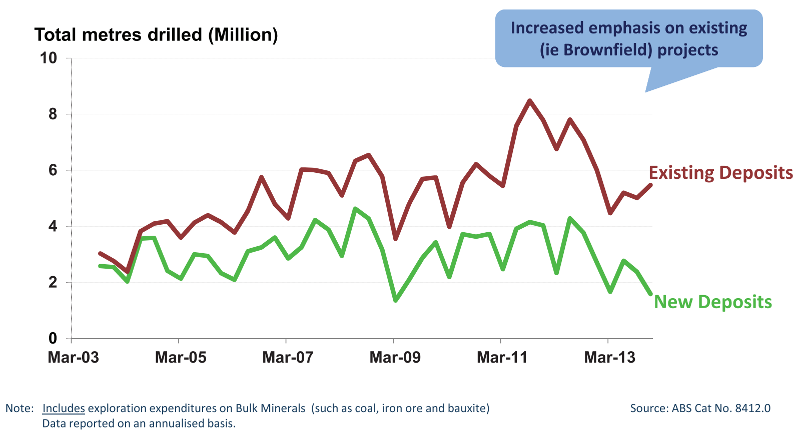

Figure 2. *Amount of exploration drilling in Australia (Sep 2001 – Dec 2013). Source: Schodde, 2013.*

which will be good news for many ASEG Members!

Canada introduced a tax incentive scheme in the early 1980s. Between 1987 and 1991 around C$3b, or 93% of exploration expenses, were covered by the scheme (including petroleum incentives). In 2006, the scheme funded around C$600m in exploration, or a 3.5× return on the cost of the scheme to the government. The Canadian share of global mineral exploration rose by 50% to around 18% in the years following introduction of the scheme. Currently there are various incentives in different Canadian states, with some wind-back of previous schemes.

In recent years, over A$1b was spent annually on Australian mineral exploration (outside of bulks), hence a A$100m credit over three years appears to be too low. There are potentially hundreds of exploration companies in Australia that may apply for the scheme. An annual cap of A$50m rising to A$100m is more realistic, otherwise the scheme could prove token, with significant scale-back for applicants, minimising the desired impact.

A report by KPMG (2013) suggested the flow-on net benefit from an un-capped scheme to Australian tax revenues would be A$106 to A$283m/a. Numerous other Australian studies conducted in recent years have come to a similar conclusion; the benefits of the scheme far outweigh the cost.

It is possible to limit the scheme to prevent distortions. For instance, limiting the credit per company to A$1m or A$2m/a would favour smaller companies who currently struggle for funds. Additionally, limiting the credit individuals can claim per company, to say A$100 000, could prevent distortions by major shareholders (and directors). Evidence out of Canada suggests individuals on the top tax bracket, many of whom allegedly have little interest in the underlying securities, have used most credits. It may also be worth considering a reduction in the credit to 20 or 30% (rather than an amount based on taxable income brackets) and including non-taxpayers (like self-funded retirees many who pay no tax but often have plenty of cash to invest). The more investors attracted to the sector, the better. Why construct a bias towards the top tax bracket?

What the scheme should be aiming to do is to divert a small portion of the unproductive money sitting in bank deposits: all A$1 736b of it (APRA 2014) and dividend paying stocks (many of which are no longer investing in Australia in a meaningful way) into real risk-capital, which has a demonstrated outstanding return to the nation.

If we replace all those mines, which may close over next decade, by continued exploration and pre-development, we could preserve hundreds of thousands of jobs (direct and indirect) and billions in state royalties and federal tax receipts. The risks associated with mineral exploration are extreme but the benefits to the taxpayer clear – therefore tax benefits should be generous.

Sentiment towards junior companies in Australia has picked up in recent months, as investors realise the ASX indices are mature and that future growth will come from new sectors, including the junior resources space. Canny investors will also remember that there are always cycles within cycles. There was a lot of money to be made from the last downturn (1998 to 2003), when a number of mergers and takeovers saw 50% plus premiums common and major new groups (like FMG) were established. When one commodity cools, others often heat up (in popularity at least). The zinc price rose over 26% in the last year (excluding the recent pullback). Nickel has made an astonishing recovery, rising 34% since 2013. Next year who knows which metal will run? Tin looks good, and is back at support levels.

Let's hope the Exploration Development Incentive scheme is implemented soon and is constructed in the best way to attract new money and investors to junior explorers. A meaningful amount of money (hundreds of millions) flowing through the sector would get the drill rigs turning and lay the foundations for the next group of major discoveries, like the Nova nickel and DeGrussa copper deposits recently found in Western Australia.

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***Geoff Muers** is the Principal Consultant at Mine Invest. He has been advising clients on mining equities for the past eight years and has worked with the mining industry for the last sixteen years. He currently consults to resources industry investors on all stages of projects from exploration through to production.*

Update on Geophysical Survey Progress from the Geological Surveys of Western Australia, South Australia, Northern Territory, Queensland, New South Wales, Victoria and WA Department of Water (information current on 12 September 2014).

Tables 1–3 show the continuing acquisition by the States and the Northern Territory of new airborne magnetic, radiometric, gravity and AEM data over the Australian continent. All surveys are being managed by Geoscience Australia (GA). There are no new surveys listed in this issue. Further information is available from Murray Richardson at GA via email at murray.richardson@ga.gov.au or telephone on (02) 6249 9229.

Table 1. Airborne magnetic and radiometric surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km^2)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Coompana	GSSA	GA	TBA	TBA	TBA	Survey design is underway	The proposed survey may cover all or part of Noorina, Wyola, Cook, Coompana, Nullarbor, Ooldea, Maurice, Wells and Birksgate standard 1 : 250 000 standard map sheets				
Dunmarra	NTGS	GA	GPX Surveys	28 Jun 2014	103 985	400 m 80 m N–S	36 280	77.4% complete at 11 Sep 2014	TBA	PV 170 – Jun 2014 p24	TBA

Table 2. Gravity Surveys

Survey name	Client	Project management	Contractor	Start survey	No. of stations	Station spacing (km)	Area (km^2)	End survey	Final data to GA	Locality diagram (*Preview*)	GADDS release
Sir Samuel – Throssel	GSWA	GA	IMT	19 Jun 2014	11 702	2.5 km regular grid	73 800	100% complete at 7 Sep 2014	TBA	PV 171 – Aug 2014 p39	TBA
West Amadeus	NTGS	GA	Atlas	29 Jun 2014	8127	4 km regular with areas of 0.5, 1 and 2 km infill	45 050	100% complete at 11 Aug 2014	TBA	PV 171 – Aug 2014 p39	TBA
Southern Thomson	GA/ GSNSW/ GSQ	GA	Atlas	17 Jul 2014	3660	8 traverses at 333 m station spacing	TBA	100% complete at 17 Sep 2014	TBA	PV 170 – Jun 2014 p24	TBA
Gippsland	GSV	GA	Atlas	30 Jun 2014	1440	12 traverses at 500 m station spacing	8358	100% complete to 21 Jul 2014	TBA	PV 170 - Jun 2014 p25	TBA
North McArthur Basin	NT	GA	Atlas	In the week of 15 Sep 2014	7315	4 km regular grid with areas of 2 km infill; 1 area of traverses spaced 4 km apart with a station spacing of 1 km.	TBA	TBA	TBA	PV 171 – Aug 2014 p39	The proposed survey may cover all or part of Arnhem Bay, Gove, Mt Evelyn, Mt Marumba, Blue Mud Bay, Katherine, Urapunga and Roper River standard 1 : 250 000 standard map sheets

Table 3. AEM surveys

Survey name	Client	Project management	Contractor	Start flying	Line km	Spacing AGL Dir	Area (km²)	End flying	Final data to GA	Locality diagram (*Preview*)	GADDS release
Swan/ Scott Coastal Plain and Albany/ Esperance	WA Dept of Water	GA	CGG Aviation (Australia)	25 Mar 2013	8607	300/600 m	TBA	100% complete to 15 May 2014	Final data to GA 20 Jan 2014	PV 163 – Apr 2013 p17	TBA
Southern Thomson Orogen	GA/ GSNSW/ GSQ	GA	Geotech Airborne Ltd	8 Apr 2014	4 198 (3327 in survey and 871 in traverses)	5 km E–W	16 270	100% complete at 5 May 2014	Additional work (traverses) over the Paroo and Darling Rivers to examine the potential for new groundwater resources was completed on 5 Jun 2014	PV 168 – Feb 2014 p24	The preliminary final point-located data were initially supplied on 12 Sep for assessment by GA

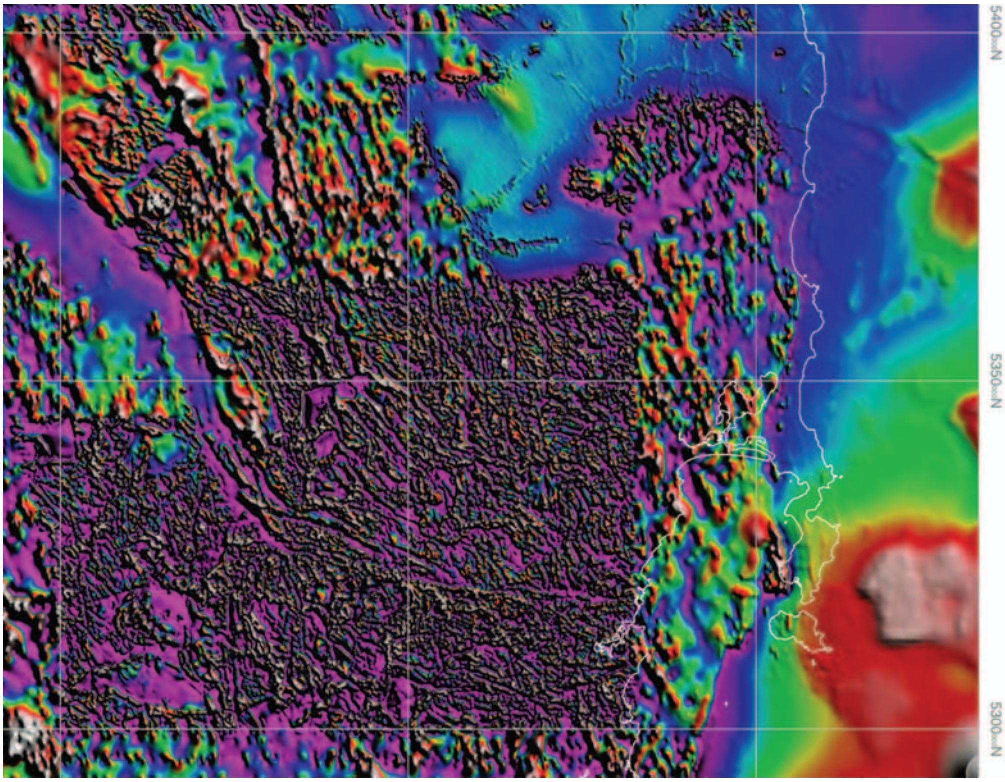
TBA, to be advised.

Revised magnetic intensity grid for Tasmania

Mineral Resources Tasmania (MRT) has revised the statewide total magnetic intensity grid by incorporating data from a major commercial aeromagnetic survey (KUTh Energy 2009 East Coast survey), as well as several other surveys that have just come out of confidentiality. Images of the new magnetic stitch are available as a 1 : 500 000 scale map in a variety of formats or through MRT's Web Mapping Service, both via the MRT website (http://www.mrt.tas.gov.au/portal/home).

Visitors to MRT's web pages will note a considerably different look and feel, reflecting MRT's migration to the Department of State Growth constituted by the new State Government. However, all the online geophysical data access functions of the old website; including the airborne survey index, gravity database and exploration report downloads, have been retained or enhanced.

For more information or advice please contact Mark Duffett on (03) 6165 4720 or via email mduffett@mrt.tas.gov.au



Excerpt from the new total magnetic intensity map of Tasmania, including the area covered by the 2009 KUTh survey, now publicly available. The magnetic stitch has a grid cell size of 100 metres.

South Australia's Online Petrophysical Database

SARIG (South Australian Resources Information Geoserver) is an award winning online map application providing statewide information for the mineral, petroleum and geothermal industries. Users are able to search, view and download information free of cost from over 400 map layers, including the Petrophysical Drillholes layer.

The website was developed by the Government of South Australia, operated by the Department for State Development, and can be found online at www.statedevelopment.sa.gov.au/sarig. The website enables geographic map view without plug-ins and while it is compatible with all web browsers it is best viewed with the Google Chrome and Firefox web browsers.

Petrophysical data is available through the Drillholes > Petrophysical Drillholes layer (Figure 1). The site currently offers magnetic susceptibility and specific gravity. Future implementation will store more data types, including downhole geophysics and vectors such as magnetic remanence measurements with inclination and declination directions.

Data can be viewed and downloaded in selected groups or per drillhole. See the instructions below to select multiple drillholes (Figures 2 and 3). Alternatively, you may view an individual drillhole's measurements with the Petrophysics tab (Figure 4). If the tab is greyed out it means no data is available.

For more information and advice contact Tim Keeping (tim.keeping@sa.gov.au).

Figure 1. *SARIG screenshot displaying the steps to select drill holes with petrophysical data.*

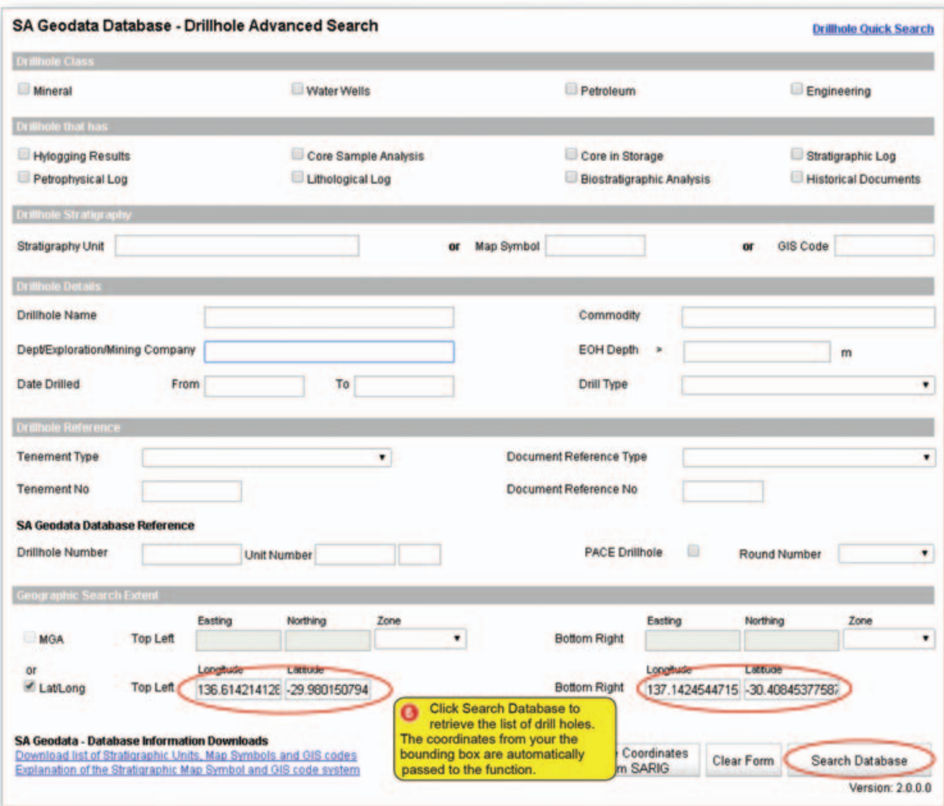


Figure 2. *SARIG screenshot of the drillhole search window.*

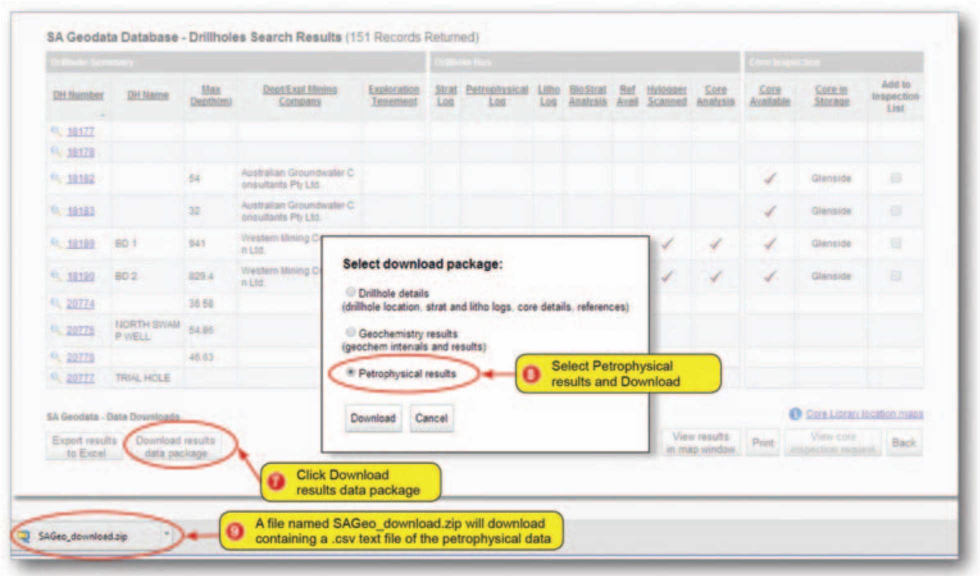


Figure 3. *SARIG screenshot of drillhole search results window with instructions for downloading available petrophysical data for multiple selected drillholes.*

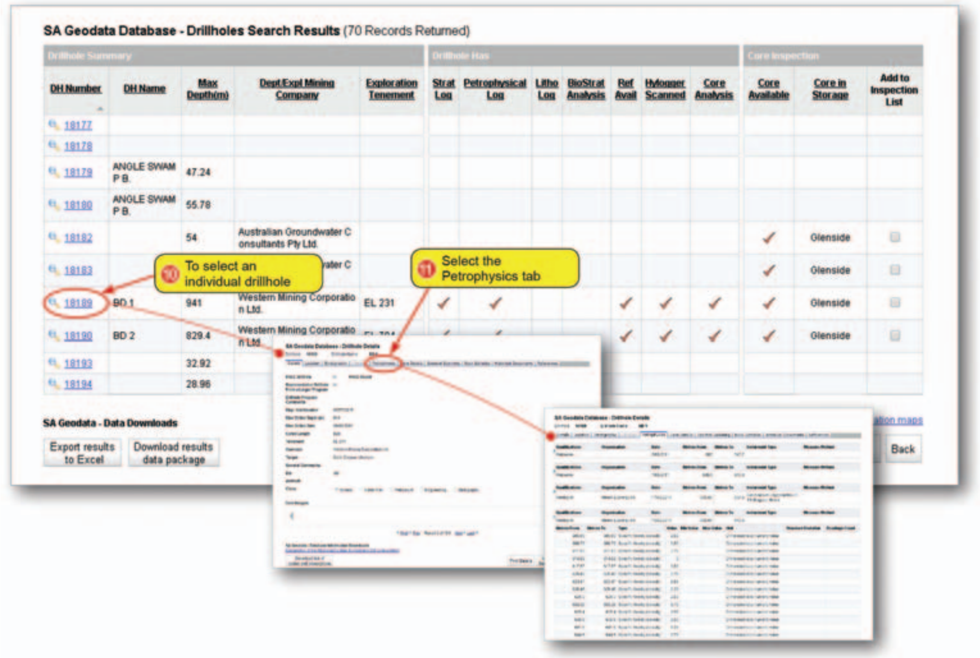


Figure 4. *SARIG screenshot of drillhole search results window with instructions for viewing and downloading available petrophysical data for individual drillholes.*

SIROTEM – Australia's first locally invented TEM system

A story of continual innovation and improvement in instrumentation over 25 years from 1972

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The need

In the early 1970s, Russia had produced a portable TEM instrument called MPPO-1 (an acronym from its name in Russian) and one was purchased by the then Bureau of Mineral Resources, Geology and Geophysics (now Geoscience Australia) and another by a large Australian exploration company. MPPO-1 was chosen because it had potential to map conductive ore-bodies, especially under the thick conductive overburden typical of most of Australia. This was because the instrument operated in the time-domain and had a large transmitter loop. However, MPPO-1 had analog function and was found to be difficult to operate and unreliable. For example, operators were required to mentally average the reading of a flickering meter display. An easier to use, more reliable instrument with a more objective measurement, preferably digital, was needed.

At this same time, other TEM systems were in operation in North America, however, they did not record signal at sufficiently late times to allow for the delaying effect of Australia's conductive overburden (something that is not commonly encountered in their region). Furthermore, they were not designed to reject the 1000 times higher levels of electromagnetic noise encountered in the tropical regions of Australia.

Meeting the challenge

In 1972, the CSIRO Division of Mineral Physics, under the leadership of Dr K. G. McCracken, took up the challenge to meet the needs of the Australian industry. While learning from the systems existing at the time, it was clear that it was necessary to go back to first principles and establish necessary design goals. These included (a) a large transmitter moment combined with selectable late-time delays to yield deep penetration and (b) signal processing that would provide the highest possible noise rejection in the shortest measurement time. A list of all the original design goals is given in Appendix 1.

Over the next 4 years a team including Ken McCracken, with his previous experience in space physics, Dr Jock Buselli, Brian O'Neill and Phil Pik, assembled a prototype TEM system using available laboratory equipment including a multichannel analyser for stacking data. For a fuller description of this prototype, see Buselli (1974). From that experience, and to make a more field-friendly unit, they designed and tested a digital unit using 8 bit A/D convertors and the latest developments generally in electronics and software including, probably for the first time in a geophysical field instrument, a CMOS microprocessor. This instrument was called SIROTEM recognising it as a TEM instrument from 'SIRO', the colloquial name for the CSIRO. For a full description see Buselli and O'Neill (1977). Some unique aspects of the design were patented in Australia and the USA.

Three prototypes were built and field tests were conducted over ten known ore-bodies, to develop 'case-studies' including at Cloncurry (Buselli, 1974), Woodlawn (Buselli, 1977, 1981) and Elura (Buselli, 1980a). Other sites included Mt. Bulga (Buselli, 1980a, 1991) and Teutonic Bore (Buselli, 1980a; Buselli *et al.*, 1986). In August 1977, Jock Buselli took a SIROTEM to the Caucasus Mountains of the USSR to compare it to the latest Russian TEM, MPP-4, which it did very favourably (Buselli, 1980b). In October 1980, Ken McCracken demonstrated a SIROTEM near Hyderabad, India. At such sites some new aspect of the measuring regime was often revealed such as atmospheric ('sferics') noise (see McCracken and Buselli, 1981) and superparamagnetism (SPM), the latter first detected at Elura (Buselli, 1980c, 1980d, 1982, 1991; Clark, 1980). The understanding and resolution of these latter phenomena, in particular, are a whole separate story which may be told elsewhere. The SIROTEM team at CSIRO continued to improve on the system and develop accessories such as a separate borehole probe, a separate receiver, a separate transmitter and improvements to the measurement software and data presentation (e.g. Smith *et al.*, 1996). (See also 'Subsequent development of additions and improvements to SIROTEM' and References.)

In 1979, SIROTEM won the prestigious international 'IR-100' award for excellence in industrial design, the first time this award was granted to an Australia organisation for the previous nine years. Examples of the calibre of other recipients of this award are NASA, MIT and GE.

Industry support

In 1975, AMIRA (www.amirainternational.com), an association of mining and exploration companies that sponsors collaborative research projects, funded Project P74 (1975–1977), enabling CSIRO to develop a commercially acceptable version of SIROTEM. This was the first of five AMIRA projects over the next 20 years tasked with developing the SIROTEM system and improvements and accessories. See a full list of project titles and other details in Appendix 2. Twenty mining companies supported one or more of these projects for a total value of nearly $5 million. This was a large amount for one instrument development at this time. See a full list of SIROTEM sponsors in Appendix 2. Developments that resulted from these projects are described in 'Subsequent development of additions and improvements to SIROTEM'.

Commercialisation

In 1976, as required of all government developments, the right to commercialise SIROTEM was tendered to private industry. Following an unexpectedly large number of respondents, 36 in fact, Geoex Pty Ltd of Adelaide was awarded the licence to market SIROTEM world-wide. In 1982, the marketing rights to SIROTEM followed Roger Henderson from Geoex to EG&G Geometrics International Corp. in Sydney, and in 1986 to Geo Instruments Pty Ltd, also in Sydney.

The first commercial production of 10 units was designated 'Mk I' and, electronically, was essentially a copy of the prototype provided to Geoex by CSIRO but housed in a robust case. The units were manufactured by MCI Pty Ltd, also of Adelaide, under licence to Geoex. Figure 1 is a photo of a Mk I console and associated battery pack. The assembly was in the form of individual circuit boards in a 'rack-mounted' style case with a separate power supply. In addition to the individual transmitter and receiver electronics, ADC, MPU and interface cards, the unit contained a digital battery-powered printer for data display. Appendix 3 lists the main specifications of the Mk I. A separate cassette recorder was offered for data storage and manipulation, the latter including conversion of signal voltages to apparent resistivities. By now the original design goals (see Appendix 1) were achieved and in most cases exceeded. Some of the early purchasers of the ten Mk I units manufactured were sponsors of Project P74 and other local mining companies but also, three were sold to other countries. See Appendix 4 for a list of all purchasers of the Mk I SIROTEM.

A story may well be true that, because the first unit was not finished in time for the pre-arranged formal handover to the first buyer, a house brick was included in the case so as to simulate the correct weight.

SIROTEM has a rare distinction of being a geophysical instrument mentioned in Federal Parliament as recorded in Hansard on 4 April 1979. In answer to a question from Senator Elstob, the then Minister for Science, Senator Webster, provided details of its development and manufacture, how many had been sold and exported and even the price at the time!

Soon after the completion of the Mk I model, ways of improving the unit and making it more field worthy were devised by Geoex, including the incorporation of a cassette tape for data storage and retrieval in a carry case opening to a flat instrument panel. Figure 2 is a photo of the front panel of this new model, designated 'Mk II'. Appendix 3 lists the main specifications with a comparison to the Mk I. Orders for this Mk II model were received from 1979 and altogether 50 Mk IIs

Figure 1. *Mk I console and battery pack.*

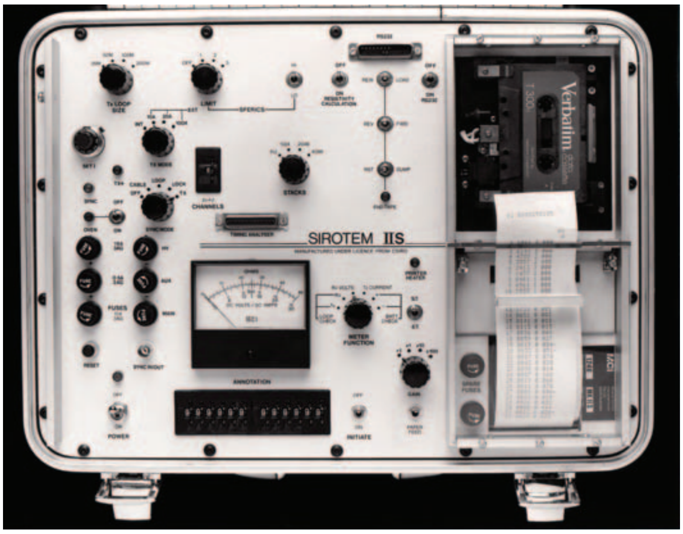

Figure 2. *Front panel of Mk II console.*

were manufactured and sold by 1990 to 20 separate countries. See Appendix 4 for the location and type of organisation of the purchasers of the first 27 Mk II SIROTEMs of which 10 were sold to seven foreign countries.

One customer for the Mk II, Arco Oil and Gas of Texas, had an unusual application; that of measuring the thickness of oil pipelines in the Arctic to reveal their internal corrosion. Due to the extreme cold, the exposed pipelines are normally wrapped with insulation but in this area, to prevent the Caribou eating the insulation, another layer of thin steel was added. This layer prevented the normal use of ultrasound to measure the pipe thickness. Brian Spies, an early Australian exponent of TEM who was working at Arco at the time, recognised the problem as not unlike conditions encountered in the field in Australia in the search for ore-bodies. That is, the thin steel was like the

Figure 3. *Front panel of Mk 3 console.*

conductive overburden and Brian knew that SIROTEM, with its late time delays, had the ability to penetrate this. A US Patent, no. 4 839 593 dated 13 June 1989, with Brian as the inventor (Spies, 1989), described this particular use of the instrument, which was later adopted by Rontgen Technische Dienst, an NDT company in The Netherlands, on behalf of Arco.

Yet again, in the late 1980s, a radical new design was developed and produced as the 'Mk 3' model, which incorporated dual microprocessors, all previous improvements and added a 3-receiver input, solid-state memory and an LCD screen resulting in half the weight of the Mk II and a slimmer case. A sferics reduction algorithm developed by CSIRO was also added (Buselli and Cameron, 1996). Other refinements continued to be added through to the late 1990s. Figure 3 is a photo of the front panel of the Mk 3 and the main specifications are given in Appendix 3, which shows the progressive developments and improvements in specifications from each model to the next. Eventually over 60 Mk 3s were sold around the world making a grand total of over 120 SIROTEMs for all three models. It is interesting that later sales were almost exclusively to foreign countries.

In the late 1990s, advances in computers suggested the possibility of a version incorporated into a rugged PC (Mk 4?). This possibility was not pursued at the time, due to a change in company ownership, but it was essentially achieved a later time by another group (see ' 'Son' of SIROTEM').

Demonstrations and exhibitions

The value in physically demonstrating the attributes of the instrument to prospective users was recognised at the outset, and this was assisted by a number of case-studies developed by the CSIRO (see the section on 'Meeting the challenge'). Also, a large number of field demonstrations and exhibitions were made by Geoex. Within 3 months of the licence being

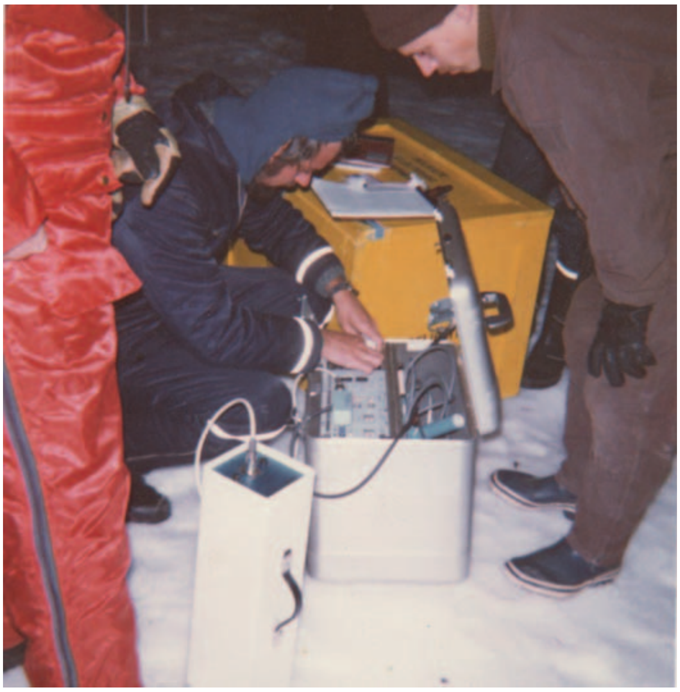

Figure 4. *A Mk I and battery pack being demonstrated north of the Arctic Circle in Finland in 1978.*

Figure 5. *Geologists from the Geological Survey of Myanmar receiving training on their Mk II and RVR-1 in 1987.*

awarded in October 1977, Geoex personnel conducted a SIROTEM survey over the Cavendish test site in Ottawa, Canada to display its attributes to Canadian TEM users. Geoex also exhibited SIROTEM at 'Ottawa 77', the second decennial mineral exploration conference in Ottawa. The need for such demonstrations applied particularly in the early stages when the system was not well known outside of Australia. Later on, some repeat orders were received without any more need for a demonstration.

Demonstrations were especially necessary in countries where the initial belief that 'it can't be much good if made in Australia' had to be overcome. This necessitated many trips to most other countries where the capabilities of the technique were understood. Roger Henderson alone, as the primary SIROTEM salesperson, conducted field demonstrations in 15 countries and presented papers and exhibited SIROTEM at over 20 conferences throughout the world. Roger's second such overseas trip (the first being to Ottawa as mentioned above) was to north of the Arctic circle in Finland (see Figure 4). In addition, workshops and training sessions were organised. Figure 5 is a photo of geologists of the Geological Survey of Myanmar in July 1987 who received training on their newly acquired Mk II SIROTEM and its associated receiver coil, RVR-1. Figure 6 is a photo of geologists in Taipei, Taiwan in June 1992 participating in one of the many workshops on Mk 3 SIROTEM performed

Figure 6. *Participants in a workshop on Mk 3 in Taipei, in 1992.*

Figure 7. *A Mk II in use in Mexico in 1987.*

Figure 8. *A Mk 3 in use in the desert of Egypt in 1990.*

throughout the world. Figures 7–9 are of demonstrations and training activities in field situations in Mexico, Egypt and Sumatra respectively.

Subsequent development of additions and improvements to SIROTEM

In 1978, in AMIRA Project P94 (1978–1981), CSIRO started development of a single-component down-hole receiver probe. Also, some of the sponsors of P94, by now, users of SIROTEM, noticed some unusual transients where the signal decayed more slowly than usual at late times, a phenomenon which was investigated by CSIRO and resolved in 1980 to be due to superparamagnetic (SPM) material close to the then coincident transmitter and receiver loop cables, providing additional signal (SPM has also been discussed in 'Meeting the challenge'). This gave impetus to the development of a separate receiver coil that could be positioned away from the transmitter loop, which was the generator of the SPM.

Thus, in 1980–1982, tests were conducted at Mt Bulga and Elura on a small multi-turn receiver coil for component measurements other than vertical. This coil also proved useful to avoid SPM (Buselli, 1982). After extensive field testing by CSIRO, both a single-component down-hole probe and the multi-turn receiver coil were made available commercially by

Figure 9. *A Mk 3 in use in Sumatra in 1993.*

Figure 10. *A Mk II with a SATX-1 (on the right) and an RVR-1 (behind).*

Geoex and designated DHR-1 and RVR-1 respectively. In 1980–1985, development of a very high power transmitter supplying up to 50 Amp was undertaken by other members of the CSIRO team (Buselli, 1991; Buselli *et al*., 1983). In 1982–1984, an early-time measurement version of SIROTEM was evaluated and subsequently incorporated in SIROTEM Model II. This allowed for shallow investigations such as soil salinity and geotechnical targets (Buselli, 1985; Buselli *et al*., 1990; Davis *et al*., 1991). In 1984, development commenced on a medium-power transmitter (20 A) with crystal clock synchronisation to the SIROTEM. This was later made available commercially and designated, SATX-1. Figure 10 is a photo of a SATX-1 with an RVR-1 behind it.

Many of these subsequent developments were sponsored by AMIRA Project P136 (1981–1984) which also included development of an induced polarisation (IP) receiver plug-in. This latter addition was never offered commercially. Aids to interpretation in the form of analogue model studies were sponsored by Project P212 (1986–1989) and software developments for rejecting noise such as sferics by statistical algorithm were provided by Project P250A (1990–1994).

As Mk 3 SIROTEM now had three receiver inputs, a 3-component downhole probe was a logical addition to the SIROTEM accessories and in 1990 a prototype was devised by Jim Cull of Monash University. In 1993 this was developed as a commercial product by John Pope and Phil Palmer of MCI and designated 'Vectem'.

Airborne SIROTEM

The operation of SIROTEM as an airborne system would greatly speed up survey coverage. However, the merit of SIROTEM as a type of TEM system would rely heavily on the area of the transmitter loop: the bigger the better. Ideally therefore, a large aircraft or a powerful helicopter would be used to fly the survey, but this would add to the overall cost and difficulty of the operation. Also, to comply with the increased speed of an aircraft, the stacking time, a great improver of signal to noise ratio, had to be reduced. This generally meant that an airborne operation would only be possible semi-airborne, either with the large transmitter loop on the surface and the receiver flown over it, or with a not so large transmitter loop towed by an aircraft. However, in 1989, the value of an airship, which was available at the time, was recognised by Jim Cull (Cull, 1989) for the large area it provided for the transmitter loop together with slow speed – which provided close-spaced sampling. One trial of this platform out of Sydney was featured in the ABC-TV science program *Beyond 2000*. In the early 1990s, SIROTEM technology was applied to a fixed-wing platform in an off-shoot development called SALTMAP (Duncan *et al*., 1992).

Distributed acquisition

A final innovation to SIROTEM, before it was superseded by the latest computer based system, was to have multiple receivers throughout the survey area recording transients from one large transmitter loop. This technique is similar to that used in seismic acquisition with arrays of geophones. To have a quantity of receivers required them to be less expensive than existing 'RVRs' and this was achieved using coils wound as circuit track on 50 cm square circuit boards. The receivers were synchronised to the transmitter pulse and readings were stored in them for subsequent 'harvesting' by a main acquisition computer. This development was called ARTEMIS (Array Receiver TEM Intelligent System). Such multiple receiver arrays would also improve on semi-airborne operations (see 'Airborne SIROTEM').

'Son' of SIROTEM

When it was apparent that a radically new model (a 'Mk 5') could be developed with the latest computing technology, Dr Jim Cull and Dr Duncan Massie at Monash University made this a reality using a full Pentium processor with 500 kHz sampling and a touch-screen for operation and display. This enabled display and interpretation software to be installed to allow for initial interpretations to be done in the field with colour displays. Apart from this, and other advances in improving data quality, the fundamental field operation of the system is the same as for SIROTEM. The new model was commercialised as 'terraTEM' and in just the first 5 years of production more units were exported than for SIROTEM in total.

SIROTEM look alikes

'Imitation is the sincerest form of flattery'

In the early stages of SIROTEM's development, when its use of microprocessors was a rarity, an institution in China purchased a SIROTEM complete with a full set of spare circuit boards. While they were not able to obtain the particular microprocessor separately, they duplicated the SIROTEM using the microprocessor on the spare board. It was then accepted by the local users that this 'Chinese SIROTEM' was better than the other locally made TEM units (Chinese SIROTEM agent, pers. comm.).

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Appendix 1. Original design goals of SIROTEM

- Digital signal processing
- Minimum 20 windows to be sampled simultaneously
- Windows contiguous to cover entire transient
- Stacking depth of up to 256 transients
- Bipolar pulse for noise cancellation
- Repetition rate a multiple of mains frequency
- Printer output
- Light weight, yet large transmitter moment
- Single, separate, small battery power pack

Appendix 2. AMIRA projects related to SIROTEM and sponsor companies

Projects

Project name, period, cost to each sponsor and no. of sponsors shown.

(1) P74 – Improvement of Electromagnetic Exploration Techniques and Interpretation, 1975–77, $30 000, 5.
(2) P94 – SIROTEM Technology, 1978–81, $123 000, 8.
(3) P136 – Advanced EM & IP Techniques, 1981–84, $327 000, 12.
(4) P212 – Field and Model Studies for TEM Interpretation, 1986–89, $146 000, 8.
(5) P250A – Improved TEM Detection of Massive Sulphide Orebodies, 1990–94, $67 000, 6.

Sponsor companies (listed alphabetically)

Company: Projects supported

Aberfoyle Ltd: 2, 3, 4 & 5
Anaconda Aust. Inc.: 3
BHP: 1, 2, 3 & 5
Billiton Australia: 4
Carpentaria Exploration Co.: 1, 2 & 3
Chevron Exploration Corp.: 4
CRA Exploration P/L: 2, 3, 4 & 5
CSR Ltd: 2
Esso Aust. Ltd: 3
Goldfields Exploration P/L: 4
Jododex Aust.: 3
Mt Isa Mines Expl. P/L: 5
Noranda Aust. Ltd: 3
North Broken Hill Ltd: 1 & 4
Pacminex P/L: 1
Peko-Wallsend Ltd: 2 & 3
Seltrust Mining Corp. Ltd: 3
Shell Co. of Aust. Ltd: 2 & 3
Swedish Geological Co.: 4
Western Mining Corp. Ltd: 1, 2, 3, 4 & 5

Appendix 3. Specifications of SIROTEM Models I, II, and 3

Specification	Mark I	Mark II	Mark 3
Internal_transmitter			
Waveform	Rectangular, bipolar. On time equals off time		
Repetition rate	25 Hz to 1.39 Hz	25 Hz to 1.39 Hz	25 Hz to 0.12 Hz
Current output	10 Amps	10 Amps	10 Amps
Voltage output (max.)	24 Volts	24 Volts	24 Volts
Receiver			
Input channels	1	1	3
Measurement range	0.4–165 msecs	0.4–165 msecs	0.05–2000 msecs
(later option)		0.05–165 msecs	0.008–2000 msecs
No. of Windows (max.)	32	32	53
Window width	0.4–25.6 msecs	0.4–25.6 msecs	0.05–410 msecs
(later option)		0.05–25.6 msecs	0.006–410 msecs
Voltage resolution	1 nanovolt	1 nanovolt	1 nanovolt
Stacking	2 to 4096	512 to 4096	2 to 9999
Gain	N/A	0.1,1,10,100	0.1,1,10,100
Data entry	Switches	Switches	Keyboard
Mains frequency rejection	By cancellation from repetition rates		
Sferics rejection	20 pulses/min.	Software	Software
Display and Interfaces			
Display	Printer	Printer	LCD
Data Storage	Optional	Cassette	Solid state
Resistivity Calculation	For 100 m Tx loop	For 4 loop sizes	Any loop size
External Interface	N/A	RS232C	RS232C
Synchronisation	N/A	OXCO	OXCO
Physical			
Operating temperature	−20 to +45°C	0 to 45°C	0 to 45°C
Weight of console	8 kg	13 kg	7 kg
Dimensions of console	44.5 × 34 × 14 cm	46 × 34 × 26 cm	46 × 34 × 16.5 cm
Options	Cassette Rec.	2 time series	4 time series
Accessories		Down-hole probe	Sep. surface coils
		Sep.surface coils	20 A extnl. Tx
		20 A extnl. Tx	Down-hole probes

Tx = transmitter. OCXO = Oven controlled crystal oscillator.

Appendix 4. Early users of SIROTEM

Purchasers of the 10 Mk I SIROTEMs produced (includes 3 in other countries, 1 in Finland, 1 in Sweden and 1 in UK. All others are Australian companies * denotes an original sponsor)

BHP (2)*
CSIRO/BMR
Geopeko*
Institute of Geological Sciences, UK
Shell Metals*
Soumen Malmi, Finland
Univ. of Adelaide
Univ. of Lulea, Sweden
Western Mining Corp.*

The first 27 purchasers of the MK II SIROTEM (by Country and type of Organisation)

Country: Organisation: Number

Australia: Exploration Company: 7
Australia: Contractor: 7
Australia: Government: 3
USA: Government: 2
China: Government: 2
Germany: Government: 1
South Africa: Exploration Company: 1
South Korea: Government: 2
UK: Contractor: 1
Thailand: Government: 1

Progress in deep seismic reflection transects across Australia

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The geotransect concept

In 2007, a working party of the National Committee for Earth Sciences, in association with AuScope, prepared a concept for a suite of geotransect corridors across the continent designed to implement the recommendation of the 2003 National Strategic Plan for the Earth Sciences: 'That the nation invest in a major geotransect study to gain fundamental information about the Australian plate, from its basic structure and evolution through to its mineral and petroleum systems and surficial processes'.

The transect plan illustrated in Figure 1 was used to guide AuScope investment in reflection and magnetotelluric work. The corridors build in part on the major efforts in reflection work with explosive sources, notably the 2000 km long Eromanga–Brisbane profiles of the Surat transect in Southern Queensland, which was acquired in stages from 1980 to 1986.

Australian seismic reflection database

The Australian continent has arguably the best coverage of all the continents for full-crustal deep seismic reflection data. To date, a total of more than 22 700 line-km of data have been acquired across most of Australia's major boundaries and provinces. Almost all of these data have been processed and delivered by the seismic and magnetotelluric team at Geoscience Australia.

In 1997 funding from the Australian Government to the ANSIR Major National Research Facility allowed the purchase of 4 heavy-duty vibrator sources for seismic reflection profiling together with modern recording equipment. Since the first survey in 1999 more than 12 700 km of reflection profiles across Australia have been carried out with coverage of the full crust (Figure 1).

The surveys have been supported by Geoscience Australia (GA), particularly through the Onshore Energy Security Program, the State and Territory Geological Surveys and the AuScope infrastructure program. Substantial investment from the Royalties for Regions funds in Western Australia and the Greenfields 2020 funding in Queensland have been a major contributors to the increase in coverage in these states.

Compared to the previous explosives sources, the vibrator sources allow a more rapid coverage and a large increase in the fold of reflection cover with consequent improvement in imaging quality. Current surveys use at least 75-fold cover, whereas with explosive sources it was often difficult to achieve even 10-fold. The result is an extensive pattern of large-scale reflection profiles that illuminate many of the geological features of the continent.

Demand for seismic has increased dramatically, with more than 1870 km of data collected or 'on the books' for 2014 alone. These raw and processed data provide an unprecedented view of the nature and structure of Australia's crust and upper mantle, which has led to new understanding on how and when the continent evolved and where minerals and energy resources are likely to have accumulated.

Recent surveys

With funding from the Geological Surveys of Western Australia and South Australia, AuScope and Geoscience Australia an 835 km-long profile across the Nullarbor Plain was completed at the turn of the year (2013–14). This survey forms the eastern half of the Eyre transect, which links an almost complete transect from west to east across the continent by linking the different surveys. The new profile extends from the Albany–Fraser Orogen across the Eucla Basin to the Gawler Craton and fills in the gap in a trans-continental transect including Eyre, Flinders and Surat transects (Figure 1).

In late May 2014 a 670 km-long reflection profile, funded by the Geological Survey of Queensland, was completed in northern Queensland. Known as the Cork Fault survey, these data partly complete the northern end of the Thomson transect (Figure 1). The survey also links to the previous surveys carried out in the Mt Isa region in 2006 and across to the Georgetown Inlier in 2007.

During June and July 2014, a 705 km-long survey, funded by the Geological Survey of Western Australia, was acquired along the coast road between Port Hedland and Broome, crossing the Canning Basin. This latest survey is parallel to the proposed Rudall transect (Figure 1).

Figure 1 represents the full extent of land seismic reflection profiles in Australia that provide coverage of the whole crust, together with the lines immediately offshore of Tasmania. This large body of information is held in the archives at Geoscience Australia in digital form and the images and data from each survey can be downloaded from their web site (see below).

A new seismic atlas

In addition, a compilation of images of the reflection results and accompanying geological information has been prepared,

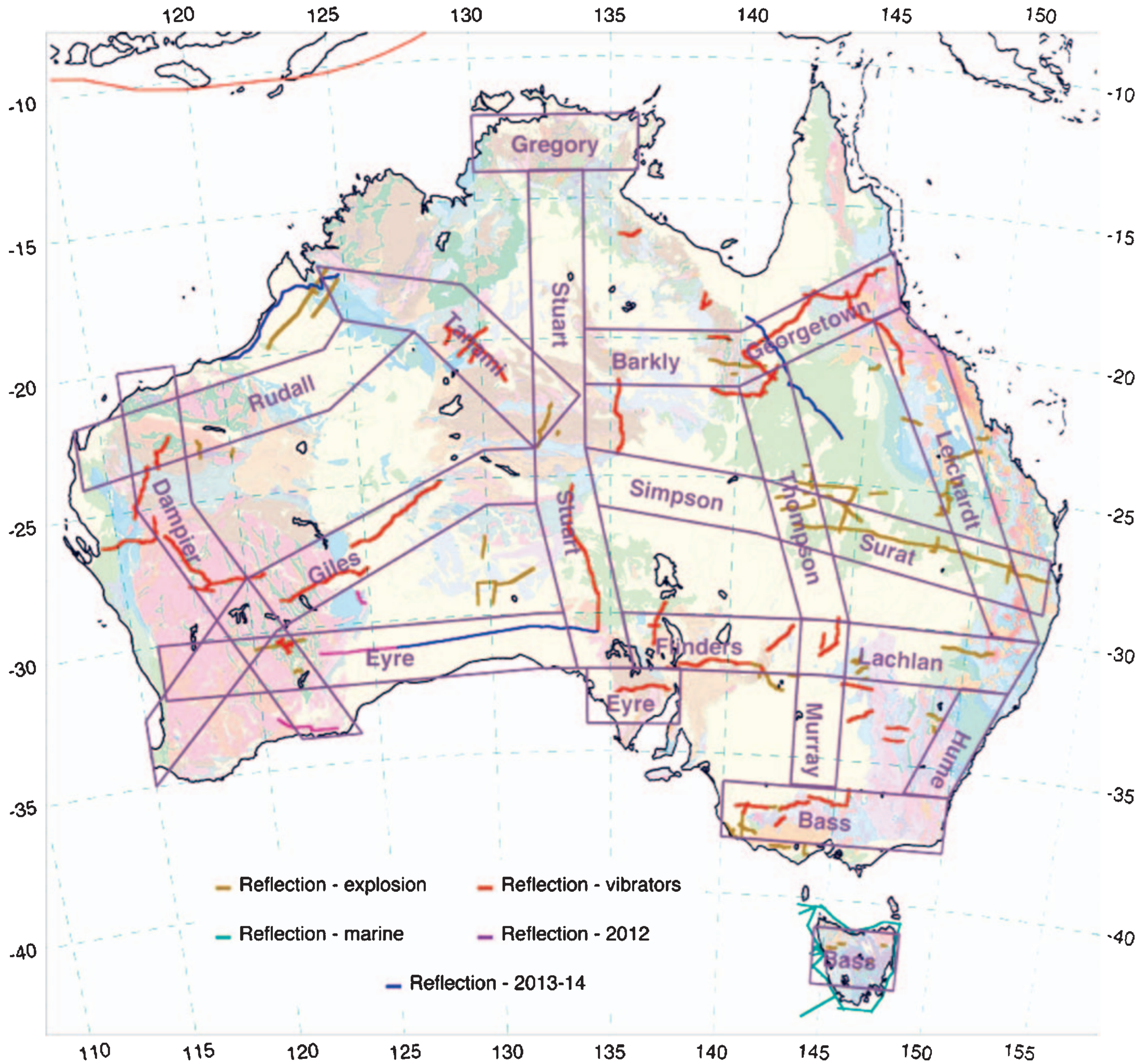

Figure 1. *Current configuration of full-crustal reflection profiles across Australia superimposed on the geological map (Source: Geoscience Australia). Transect corridors recommended by the 2007 working party are shown.*

with the aim of providing an overview of the full range of information on crustal structure and evolution contained in the reflection profiles. The publication *Deep Crustal Seismic Reflection Profiling: Australia 1978–2011* by Kennett *et al.* (2013) a co-publication by ANU Press and Geoscience Australia is available for free download as a PDF File (140 Mb). The book is also available for print on demand from ANU Press, in A4 landscape format.

Each reflection profile is presented at approximately true scale with up to 220 km of profile per page and overlap between pages. The sections were prepared to fit on an A3 page, but will stand further enlargement. Each reflection section is accompanied by a geological strip map, which shows the configuration of the line superimposed on 1 : 1 M-scale geology.

Figure 2 presents an example from the 2007 reflection profiling in northern Queensland, illustrating the major change in crustal structure at the edge of the Mt Isa Province with very different crustal reflectivity patterns. The latest 670 km-long profile in North Queensland crosses the 07GA-IG1 line illustrated in Figure 2 at approximately CDP 7000 and thus provides direct 3-D control on this complex structure that lies entirely under cover.

The compilation of deep crustal seismic results also includes a number of large-scale reflection transects, which are groups of 1000 km or longer that link across major geological provinces, and an extensive bibliography of reports and relevant publications. As new reflection surveys are released, we aim to produce a supplement with the new sections and updates of

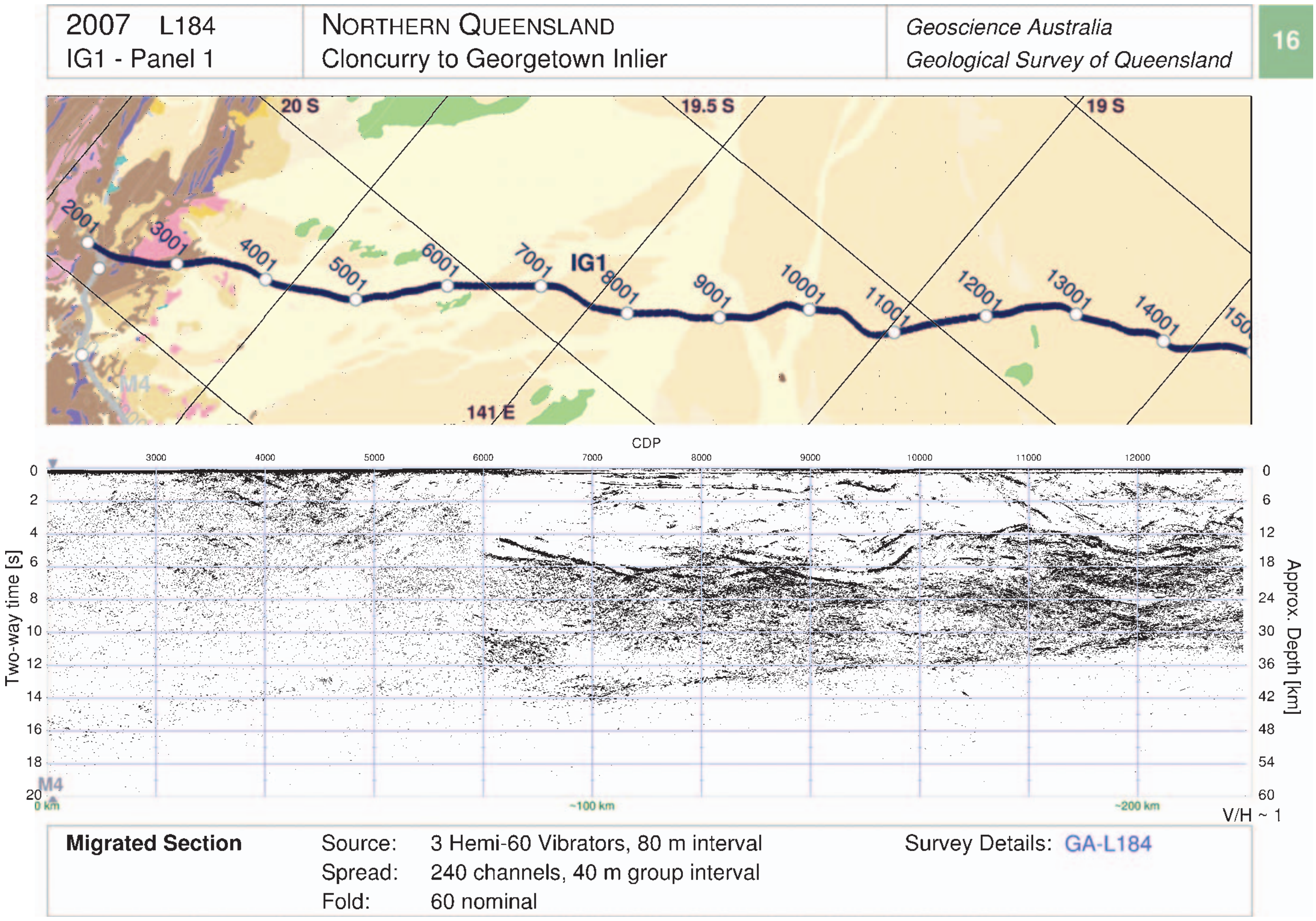

Figure 2. *Illustrative page from Kennett et al. (2013) for a section of 2007 reflection profiling in North Queensland, demonstrating the extension of the Mt Isa Province undercover and a dramatic change in crustal architecture at CDP 6000.*

older pages, where appropriate. These transects, including the latest results from 2012 surveys in the Albany-Fraser region of Western Australia, are available for free download at the Australian National University's Research School of Earth Sciences (RSES) seismology pages (see link below). The resolution is such that these long transect surveys can be plotted in large-scale formats.

Implications of the deep-crustal seismic transects for resource potential

The deep-crustal seismic reflection profiles provide one component of the information required to understand the structure and evolution of the continent and its minerals, energy and water resource potential. The seismic data need to be combined with a full suite of geophysical, geological, geochemical and geochronological results to secure maximum benefit. In regions of sparse to nonexistent basement outcrop, the reflection results allow a deep crustal image of underlying geology that otherwise would not be evident.

Having the seismic database has allowed systematic interpretation of the data, in particular the major terrane boundaries. Korsch and Doublier (2014) have produced a new map of the major boundaries, many of which are the first-order structures that control the focus of mineral systems, such as nickel and gold.

The deep-crustal seismic reflection lines have changed the way people think about a region's geology and prospectivity. For example, the deep-crustal seismic reflection data along the Bass transect in western Victoria (Figure 1) changed the interpretation of the tectonic setting to be one suggestive for Cambrian Andean-style copper mineral systems (Cayely, 2011). As a result, Geoscience Australia and the Geological Survey of Victoria are testing this metallogenic model with a new drilling programme in the Stavely Zone. Several companies are also actively exploring this region for gold, copper and other base metals.

The future

Although Australia has made remarkable strides in studying the transect corridors, many segments have yet to be addressed. Notable gaps include southwest Giles, Simpson, northern Stuart, Barkly, Gregory, Hume and Leichardt transects. There are plans for the infill of the eastern Bass transect and further surveys are planned around the northern end of the Thomson transect (Figure 1). As funds become available the priority will be to continue to complete the geotransect vision of the National Committee for Earth Sciences.

References and other web links

Australian National University Research School of Earth Sciences seismology http://rses.anu.edu.au/seismology/AuSREM/Reflection_Atlas/ (link to the long seismic transects)

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http://portal.auscope.org/portal/gmap.html (a portal for many geoscience data layers)

http://www.ga.gov.au/news-events/newsletters/minerals-alert/minerals-alert/minerals-alert-june-2014#b (for instructions on how to find the seismic data)

Kennett B.L.N., Saygin, E., Fomin T. & Blewett R.S., 2013. Deep Crustal Seismic Reflection Profiling Australia 1978–2011. ANU Press–Geoscience Australia. http://press.anu.edu.au/titles/deep-crustal-seismic-reflection-profiling/

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AEM and its application to potash exploration in Australian salt lakes

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The continuing world demand for potash (potassium salts), a crucial agricultural fertilizer, is driving a new exploration boom in the Australian minerals industry for this valuable resource, listed by Geoscience Australia (GA) as a strategic commodity (Mernagh, 2013). The Food and Agriculture Organization of the United Nations (FAO) predicts a rising demand for fertilizers, with potash demand increasing at 3.7% per annum (FAO, 2012), and Rabobank predicts that demand will exceed supply by up to 100% by 2020 (Rabobank, 2012).

Potash is mined from hard-rock evaporite deposits, the remains of ancient seabeds, or by the concentration and crystallization of potash from brines in salt lakes. Australia has no economic evaporite-related potash deposits and must rely solely on salt lake potash for its future resources (Mernagh, 2013). In most fertile salt lakes potash is harvested from brine pools located below the dry salt pan. The brines suitable for harvesting are characterised by a high potassium/chloride (K/Cl) ratio, which generally increases with increasing salinity of the brine (Mernagh, 2013). Salinity can therefore be used as a proxy to explore for potential potash resources in salt lakes. Airborne electromagnetic (AEM) surveying can be used to map the shape and size of the brine pool and thereby assist in reducing exploration costs associated with drilling. This short paper describes a few of the applications and is written in response to an industry request to GA for information on how AEM might be used to explore for potash.

There are numerous examples showing where AEM has been successfully used to map the spatial distribution of groundwater salinity. GA has a long history of using AEM to map groundwater salinity for water resource assessment through its earlier collaboration with the Cooperative Research Centre for Landscape Environments and Mineral Exploration (see http://crcleme.org.au) and more recently through the GA Groundwater Project (see http://www.ga.gov.au/groundwater.html) and the CSIRO's Land and Water Division (see http://www.csiro.au/). There are many commercial operators who also offer the same service. These surveys are normally high-resolution, have narrow line spacing (~200 m), and are designed to map salinity in groundwater to assess its suitability for drinking water, for agricultural and grazing purposes, to map aquifers and assess dryland salinity risk.

The more recent application of regional, wide line-spaced (1 to 6 km), minerals-oriented AEM datasets for potash exploration is highlighted by the minerals industry's adoption of GA's pre-competitive AEM data set in the Paterson Province of Western Australia. The companies were attracted to the region because of the availability of high quality regional AEM data, GA interpretations of palaeovalley groundwater flow, the availability of legacy borehole data through the Geological Survey of Western Australia, and the availability of tenements.

The examples shown here highlight the re-purposing of GA's AEM datasets, originally flown during the Australian Government's Onshore Energy Security Program (OESP; McKay, et al. 2011), to map salinity as a proxy for potash. The Paterson AEM survey (Roach, 2010) is a minerals-oriented survey flown between 2007 and 2008 using the fixed-wing TEMPEST® AEM system (Figure 1). The Frome AEM Survey (Costelloe and Roach, 2012; Roach, 2012) is also a minerals-oriented AEM survey (Figure 1) flown in 2010, again using the fixed-wing TEMPEST® AEM system. Both the Paterson and Frome datasets and interpretation products are publicly available through the GA website as contractor-supplied and GA Layered Earth Inversion (GA-LEI; Brodie and Sambridge, 2006; Brodie, 2010) products. The Pine Creek-Kombolgie areas of the Northern Territory were also flown during the OESP (see Craig, 2011), but these do not encompass any salt lakes, so are not discussed here.

Paterson and Frome AEM surveys

The Paterson AEM Survey (Figure 1) was primarily designed to assess the Paterson Province of Western Australia for unconformity-related uranium and copper-gold mineralisation, as well as for under-cover geological mapping. The Paterson AEM Survey data were acquired at line spacings of between 1 and 6 km for a total of 28 200 line kilometres, covering 47 600 km^2. A number of large salt lakes occur in the region, including Lake Disappointment, the Percival Lakes chain (Lakes Winifred, Dora and Blanche) and Lake Waukarlycarly. These lakes only experience water influx during catastrophic rain events associated with thunder storms and cyclones. The lakes occur in a chain along the courses of palaeodrainage systems including the Disappointment and Canning palaeorivers which, while not accurately dated, may be of similar ages to Eocene-Miocene palaeodrainage systems occurring in the Southern Yilgarn Province and Murchison region of Western Australia (Magee, 2009; Roach, 2010; English, 2011).

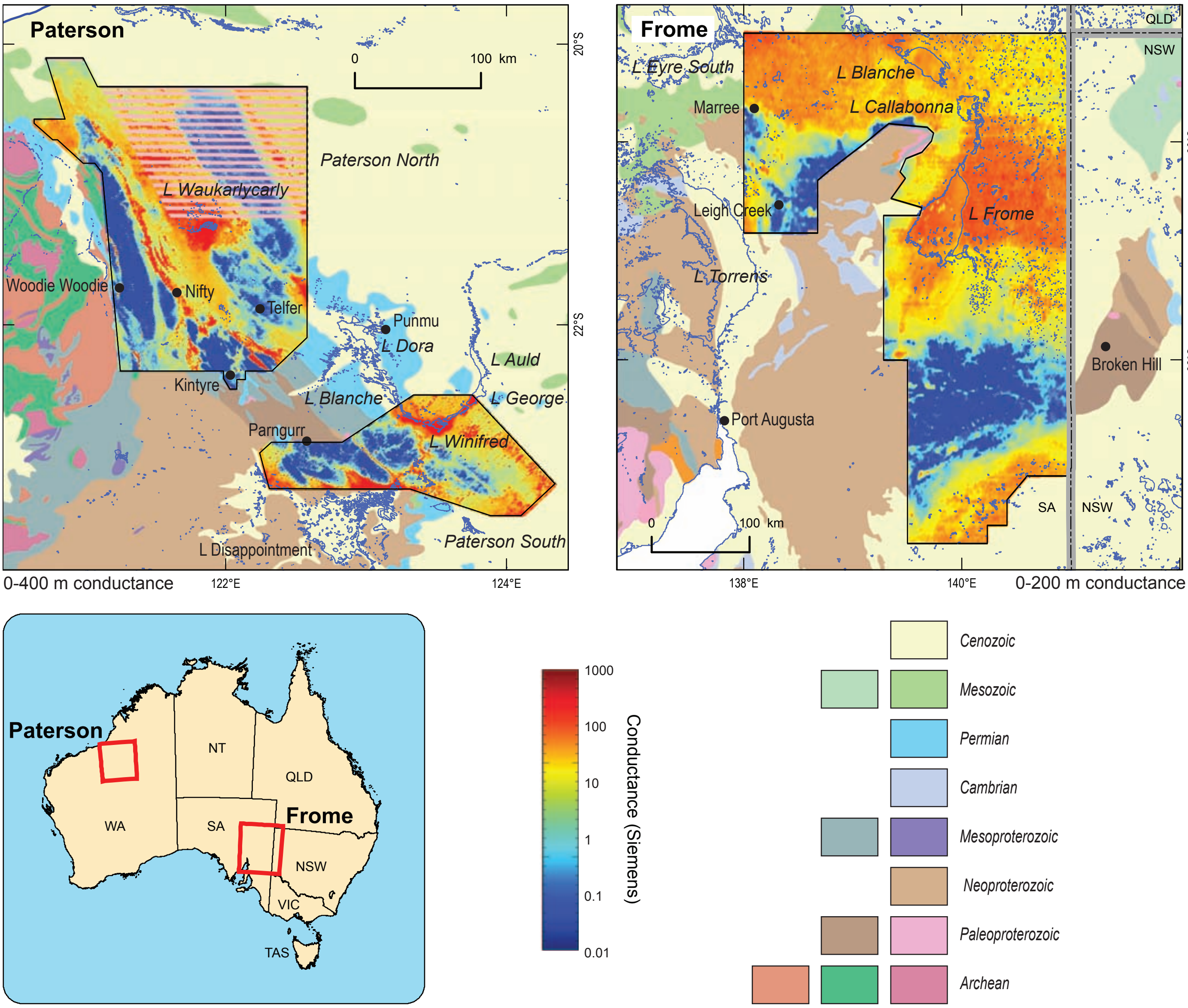

Figure 1. *Conductance images of the Paterson (Western Australia) and Frome (South Australia) AEM survey areas. The images are overlain on the Geoscience Australia 1 : 1 million scale Geological Map of Australia.*

The AEM data reveal new detail of the 3D morphology of the large palaeodrainage systems including the Canning and Disappointment palaeorivers, and show the subsurface connection between Lake Disappointment (on the Disappointment Palaeoriver) and the Percival Lakes (which follow the Canning Palaeoriver). This connection had previously been described by Beard (1973) and van der Graaf, et al. (1977), but can now be mapped in three-dimensional detail using the Paterson AEM Survey dataset (Figure 2). The AEM data show conductivity anomalies within these palaeodrainage systems that are related to saline groundwater. Legacy industry drillhole data from around the salt lakes show elevated Total Dissolved Solids (TDS) values associated with conductivity anomalies mapped using the AEM data.

Mineral exploration companies have, more recently, taken the Paterson AEM Survey dataset and interpretation report and applied the information to minerals that were not originally the focus of the AEM survey and interpretation effort. Two mineral exploration companies announced new tenements over large portions of the Paterson region including Lake Disappointment, Lake Winifred, Lake Blanche, Lake Dora and Lake Waukarlycarly, based on the regional AEM data and interpretations provided by GA.

Reward Minerals Ltd was the first company to apply for tenements over the Lake Disappointment area, based on earlier research on the potash potential of this lake. In December 2013 Reward Minerals Ltd announced that it would be taking additional tenements in the Paterson region based on AEM data and groundwater flow interpretations provided by GA (Reward Minerals Ltd, 2013). These data and interpretations showed the hydraulic connections between Lake Disappointment, Lake Winifred, Lake Blanche, Lake Dora and Lake Waukarlycarly, now recognised as parts of the Disappointment and Canning palaeoriver systems. Reward Minerals Ltd's reasoning for the additional tenements was that groundwater flow through the palaeodrainage systems had the potential to carry potash-rich fluids from the headwaters at Lake Disappointment, through the Disappointment and Canning palaeorivers to Lake Waukarlycarly and beyond.

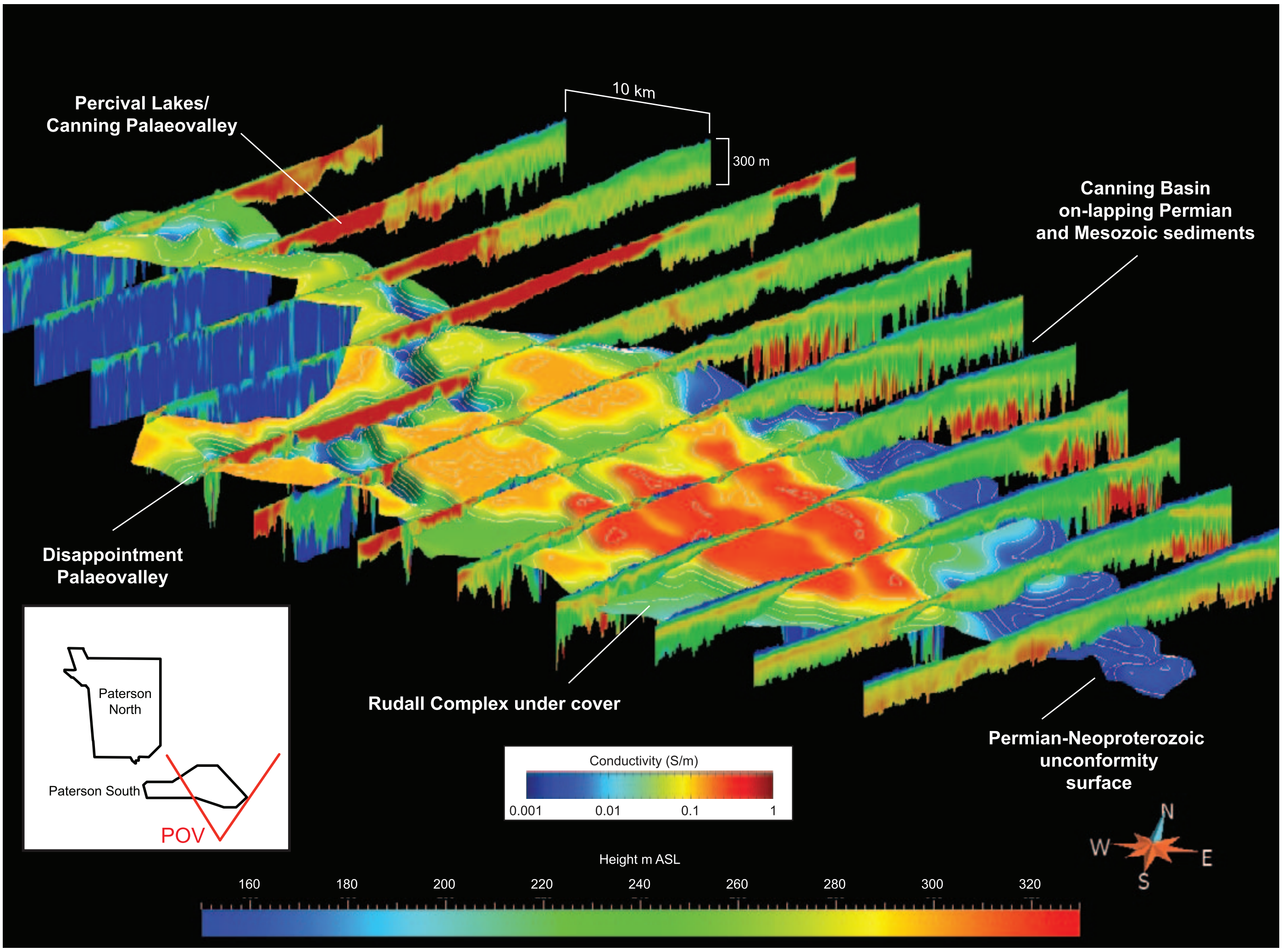

Figure 2. *3D mapping of the Disappointment palaeovalley across the Rudall Terrain, Paterson South AEM survey area, from Roach (2010).*

Similar reasoning by the Global Resources Corporation Ltd led them to apply for tenements at the outlet of Lake Waukarlycarly to the northwest of Reward's tenements (Global Resources Corporation Limited, 2014). The AEM data gave the companies certainty in deducing large scale groundwater flow systems and indicated areas where hypersaline groundwater accumulates near the Earth's surface, and has possibly concentrated potassium salts, as opposed to merely brackish water which would not have commercial concentrations of potash.

The Frome AEM Survey (Figure 1) was flown using 2.5 km and 5 km line spacings for a total of 32 317 line km and 95 450 km^2, or approximately one tenth of South Australia's area. This survey was flown at 100 m nominal altitude (a first for the TEMPEST® system in Australia) and was designed to map geology for broad scale energy minerals resource assessment as well as to map covered bedrocks suitable for potential Broken Hill-style lead-zinc-silver and iron oxide-copper-gold (IOCG) resources. Survey data provide a regional overview of the under-cover geology of much of the survey area. The data have mapped features of fertile sandstone-hosted uranium systems and have highlighted many new areas of prospectivity for energy minerals and other commodities (see Roach, 2012; Roach et al., 2014).

Mapping salinity using AEM data

Lake Frome (Figure 3) is a large salt lake located to the east of the northern Flinders Ranges and is part of the Lake Eyre Basin. In the Frome AEM Survey, the AEM data resolve geologically-meaningful patterns of conductivity in Lake Frome, which is normally dry on its surface and has groundwater salinity values up to ~10 times sea water. The highest measured groundwater TDS value for Lake Frome is 338 700 mg/L (Draper and Jensen, 1976); in comparison, sea water is on average about 35 000 mg/L TDS (Wright and Colling, 1995), which equates to about 5.4 S/m electrical conductivity (EC). Interpretations of drilling and groundwater analyses across Lake Frome by Bowler (1986) modelled the presence of a pool of hypersaline groundwater in the central portion of the Lake, with groundwater TDS increasing to >250% (250 parts per thousand), fed by vertical groundwater flow (Figure 3). Bowler's interpretation is a useful description of a cross-section of the Lake and its groundwater flow system and helps us understand the three-dimensional conductivity patterns mapped in the Frome AEM Survey dataset.

Figure 4 illustrates the empirical correlation between groundwater TDS and ground EC as mapped by the GA LEI 0–10 m depth slice. The image is enhanced using an exponential

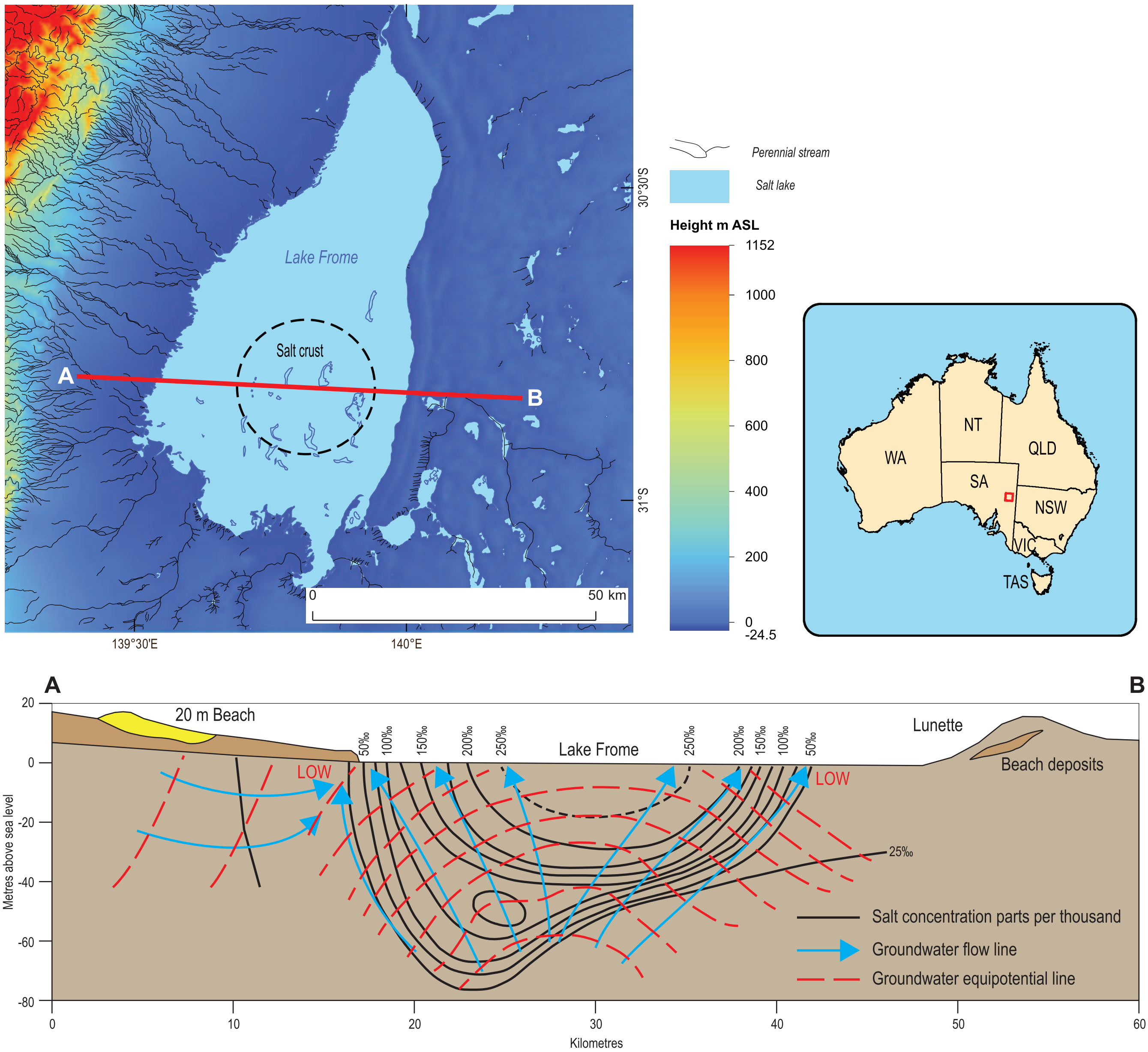

Figure 3. *Interpreted salinity and groundwater flow in a section through Lake Frome, modified from Mernagh (2013) after Magee (2009) and Bowler (1986).*

transform to highlight high-conductivity zones associated with Lake Frome and, to a lesser extent, smaller saline playas to its east and south, while suppressing low to moderate conductivity data elsewhere. Areas of low conductivity within the lake correlate with islands of gypsum sand or areas interpreted to be zones of fresh water recharge in the base of the lake. A number of small mound springs are present in the eastern part of the lake highlighting the role of recharge from the Great Artesian Basin (Draper and Jensen, 1976). These are largely not reflected in the gridded conductivity data, indicating that the aircraft did not fly over these features and that they are quite small in comparison to the 2.5 km spaced flight lines. The overall pattern of ground conductivity also confirms the interpretation of groundwater salinity in Lake Frome by Bowler (1986), who described the 'saline bulge' under Lake Frome as part of a broader discussion on the evolution of Australian salt lakes. Similar spatial correlations between TDS and EC are also seen in deeper depth slices over Lake Frome.

Further information on conductivity features related to salinity can be interpreted from using two metrics: the calculated Depth Of Investigation (DOI); and, the inversion data misfit (Phi_D). Figure 5 illustrates a highly vertically exaggerated GA-LEI conductivity section across Lake Frome that includes these two metrics.

There are many factors that can limit the DOI including subsurface conductivity, system power, waveform, noise characteristics, height and geometry. Around salt lakes the limiting factors are principally the highly conductive ground and system power, both of which limit signal penetration depth. The energy transmitted by an AEM system is absorbed when eddy currents are induced in the subsurface. As the near-surface becomes more conductive, the eddy currents are confined more closely to the near-surface and less of the energy penetrates to depth. In highly conductive areas such as Lake Frome, the transmitted signal penetration may be only a few tens of metres, whereas in resistive areas the signal penetration may be

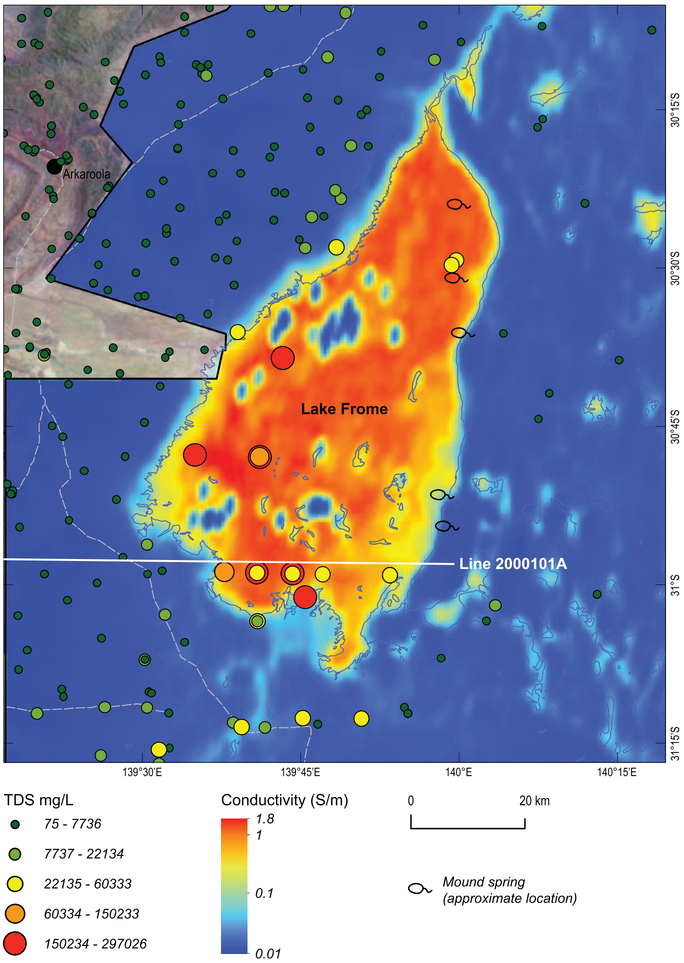

Figure 4. *Image enhanced (exponential transform) 0–10 m depth slice image of Lake Frome and surrounds from the Frome AEM Survey (Roach 2012) with groundwater TDS data overlain, highlighting the empirical correlation between TDS and ground conductivity. Groundwater data are from DEWNR (2012).*

400 m or more. Thus, in salt lakes, the poor calculated signal penetration is most likely to be directly correlated with high groundwater salinity levels.

The Phi_D indicates the ability of the inversion to fit the observed data to a preconceived geoelectrical model. Phi_D values of very much greater than 1 indicate that the inversion has struggled to fit the data; often the reasons for this may be interpreted as cultural features (metal infrastructure, electric fences, power lines) or 3D geology (non-flat-lying conductive geology) or, in the case of salt lakes, highly conductive near-surface groundwater. Phi_D may also be influenced by having poor constraints on the inversion, or through difficulty in estimating the primary field; however, it is also a useful indicator of the presence of hypersaline water in salt lake systems.

The DOI and Phi_D can be gridded, making further useful visual tools that describe the depth of reliable signal penetration and inversion misfit, which are most likely geologically-related around salt lakes. Note the correlation between shallow DOI and high Phi_D values in the bed of Lake Frome (Figure 5) indicating that the inversion fits the data very poorly in this zone. This is correlated with the salt crust mapped by Bowler (1986) (Figure 3). It is these zones of poor signal penetration and high Phi_D that explorers should look to because they indicate the presence of hypersaline groundwater with the potential for elevated levels of potash.

Care must therefore be taken with interpretations over highly conductive salt lakes. Note that there are a number of AEM systems in the market that have higher power transmitters and can detect more deeply than the system used for the Frome AEM Survey.

Once the local groundwater salinity conditions and their effects on the AEM data are understood, grids and sections of AEM data can be used to map hypersaline groundwater as a proxy for potential potash resources. Simple image enhancement of gridded AEM data can be used to map variation in conductivity correlated with salinity to highlight areas where salt is concentrated (and therefore where potash or other resources may be too) and areas where fresh water recharge occurs. Note that it is not possible to quantify the correlation of conductivity with salinity and determine the actual amount of salt in this area without additional groundwater chemistry data obtained from surface sampling and drilling.

Conclusions

Normally, AEM surveys for mineral exploration would be designed to avoid salt lakes because of the high ground EC that prevents adequate signal penetration. However, this aspect can be useful for potash exploration; AEM maps salinity gradients within salt lakes and can separate brackish from hypersaline groundwater. It is in the hypersaline groundwater that potash and other commodities may be concentrated. Thus, the ability to recognise and map hypersaline groundwater is the first step in broad-area assessment of the potential of salt lake systems for potash and other mineral resources such as lithium, boron and uranium.

The Geoscience Australia Salt Lakes Project (Mernagh, 2013) assessed the potential of Australia's salt lakes for a range of strategic resources and showed that of Australia's ~1200 salt lakes, groundwater data exists for only ~100. The study noted that many of the potassium mineral systems in Australian salt lakes are interpreted to be related to Precambrian evaporite deposits. The study concluded that in areas where source rocks are known to have potential for potash and other resources, AEM can be used to quickly assess estimates of conductivity in salt lakes, and thus salinity. Additionally, AEM can be used to map groundwater hydraulic connections between source rocks and the salt lakes to help mineral explorers with area selection.

The Australian Government-funded precompetitive AEM Surveys of the OESP were designed to deliver reliable, low noise, calibrated, fit-for-purpose precompetitive AEM data to aid research into the energy potential within the Paterson and Frome areas. The survey data and interpretations have been used in energy minerals exploration in line with their intended purpose; however, the impacts of the surveys have extended into regional mapping, mapping under cover and mapping for a variety of commodities with results much greater than anticipated.

Precompetitive AEM data and associated scientific analysis assists exploration under cover by reducing risk, stimulating investment and promoting exploration for commodities. Data and associated interpretations from regional AEM surveys in the Paterson Province have led to tenement take up for potash and show that carefully collected AEM datasets have far greater

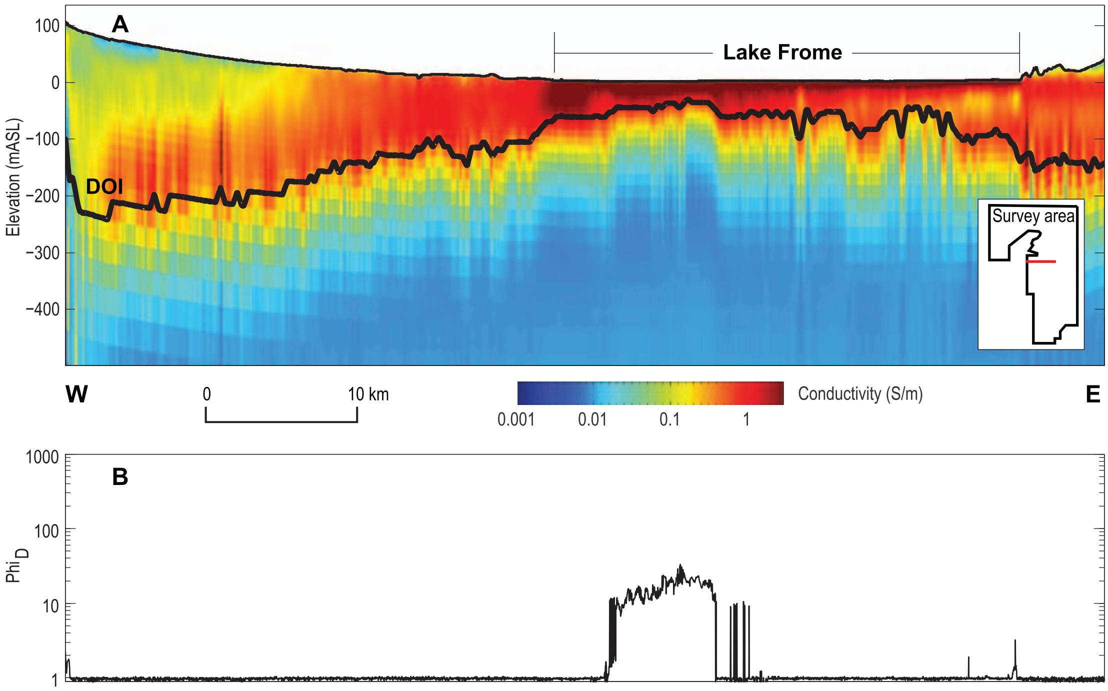

Figure 5. *Frome AEM Survey flight line 2000101A. (a) A SBS GA-LEI conductivity section, and (b) the corresponding inversion data misfit (Phi_D) profile. This diagram highlights the response of the DOI (and thus calculated penetration depth) to changing bulk earth conductivity, in this case from relatively resistive ground and relatively fresh groundwater near the Flinders Ranges in the west to highly conductive, saline groundwater in the east at Lake Frome. The line is highly vertically exaggerated compared to actual GA-LEI data products. The Phi_D is » 1 over the western side of Lake Frome indicating that the data were not fitted in the inversion, most likely due to excess salinity.*

longevity, and far wider application, than the planners originally intended.

In this brief discussion we have answered the original question put to us by an industry representative about the usefulness of AEM in mapping potash 'plumes'. Potash is an important commodity for us in Australia, and world-wide, because of its use as an agricultural fertilizer in potassium-poor soils – something that Australia has in abundance. The exploration industry needs tools that are easy to apply and can cover large areas quickly at low cost in the search for potash. We believe that carefully conceived AEM surveys are one of the most useful tools to boost knowledge of Australia's potash resources.

Acknowledgements

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Where has all the data gone?

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In a recent presentation performed at the Professional Petroleum Data Management (PPDM) conference in Perth, I spoke about the problems exploration companies can have when an exploration area that has previously been out of favour comes back into fashion.

The first thing that all companies entering a previously explored area do is assemble as much pre-existing data as possible. In Australia, effort to source this data from various public sources is usually quite fruitful. However, whilst getting 90% of the data you need is a great start, it can often be the 10% that you *can't* find that will make all the difference to your exploration efforts. The reasons behind this missing 10% are many and varied, but usually fall into two main categories. The first of these two categories is bureaucratic in nature.

As some background, it was not until 1946 that a formal government body called the Bureau of Mineral Resources Geology and Geophysics (BMR) was formed. The BMR had a general exploration view; encompassing both minerals and petroleum. The BMR later came to be known as AGSO, and then became Geoscience Australia. Through these various transitions, and with changes in its degree of control and mandate over exploration activities in Australia, data submission guidelines were created, modified and in many cases then handed over to other agencies. In 2012 a new agency, the National Offshore Petroleum Titles Administrator (NOPTA), was formed and took over administration of petroleum acreage in Commonwealth waters from Geoscience Australia, adding a new layer once again.

As time went on, and overlapping with the changes at the federal level, some states took control over their own state's exploration activities, while others maintained a hands off approach. Data was going in different directions, some to federal agencies and some to states. Sometimes data went to both, and sometimes to neither, creating holes in data sets desperately needed in contemporary exploration programmes. Depending on the state you were exploring in, whether your exploration area was on or off shore, and whether you were looking for minerals or oil and gas, you had a different government body that was interested in your activities and data.

One recent change in the oil industry has opened up a new previously unseen issue in locating historical exploration data. That change is the transition of oil companies to unconventional oil and gas targets like CSG. This transition has seen oil exploration companies looking to review data that might typically be associated with mineral exploration. Vast differences in data submission guidelines between petroleum and minerals, paired with changes in requirements at the state and federal level, means that many data sets needed by exploration companies cannot be found, or there is simply uncertainty about where this data actually resides.

The second category of issue that has created this missing 10% cannot be blamed on bureaucracy and rests firmly on the industry itself. The government, with the best of intentions and much effort, cannot police everything and everyone. Even with the well written and clear submission guidelines in existence today, the government cannot always control issues such as companies going into receivership and not performing their submission, or mergers and acquisitions that created uncertainty as to what had been submitted by one party and who was responsible for it moving forward. I think it would be safe to say that some companies simply ignored the policies and guidelines. Some then took the data overseas when they left or simply kept the data in a storage shed in the event that they might need it again later.

I guess my message to the industry is as follows – data submissions are necessary, good for the industry and are simply not that complicated. Various guidelines and online resources are available to assist with the process in each state and at the federal level. In addition, there are service companies and consultants who can assist where uncertainty in the process is required. As an industry we need to lift our game and get these valuable data assets back to the rightful owners on time. It is likely ourselves that will benefit from this when we need data in the future.

Prospect risking and sparse data

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Most interpreters have been involved in prospect risking meetings where new prospects in the company's portfolio are assigned a chance of success. Prospect risking is one of the black arts of exploration that often involves guesswork and manipulation based on the sometimes biased ideas of the prospect review committee. But, rather than using dodgy brown numbers that have no explanation, maybe there is a way to use the available data.

Last week I was in a meeting which was trying to determine the probability of finding a good porosity reservoir rock at a depth of 5000 m. During the discussion the porosity vs depth plot (Figure 1) was projected on the screen of the meeting room. It showed no well in the area had been drilled to that depth. One of the geologists remarked 'It's a guess – we don't have any data'. Actually there is a lot of data – it's not obvious, but maybe we can analyse the data we have and calculate the chance of finding an effective reservoir.

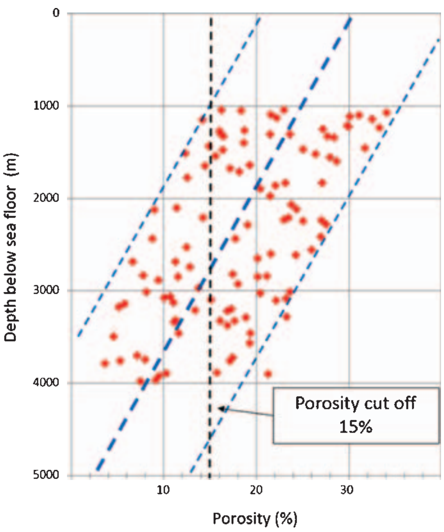

Figure 1. *Plot of porosity vs depth below sea floor using data from a number of wells. (Note: for this article I have not used real data.)*

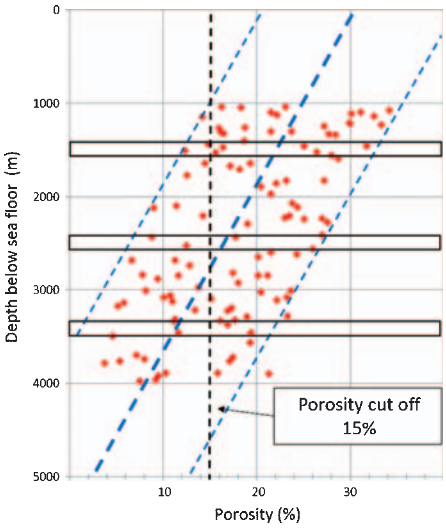

Figure 2. *Porosity vs depth plot showing linear trend lines extrapolated to 5000 m below sea floor and the porosity cut off (15%). The extrapolated trend lines indicate that at 5000 m no effective reservoir is expected. Also shown are three windows around 1500, 2500 and 3500 m that are used to calculate probability of a reservoir sand with greater than 15% porosity.*

I have devised a method that yields a chance of success based on extrapolating the data available.

Let's assume that an effective reservoir requires at least 15% porosity. The most common technique, extrapolating the data bounds of the plot of porosity vs depth, suggests that there is no chance of finding an effective reservoir at 5000 m below sea floor (Figure 2). But this conclusion is based on a linear trend. Is the cloud of data on a straight line or curved trend?

I suggest that we calculate the probability of finding effective reservoir in a number of different depth windows and create a probability vs depth plot. For example, in the depth window 1400–1600 m there are ten data points, two are below the porosity threshold and eight are above it so the probability of good reservoir is 0.8 or 80%, which is plotted at the midpoint depth of 1500 m. Taking two further windows gives probabilities of 60% (3 out of 5 points) and 50% (2 out of 4 points) at 2500 and 3500 m respectively

By plotting these three points and fitting a curve through them (Figure 3) we can estimate the probability of effective reservoir at 5000 m to be 36%. This is far better than the zero chance obtained by linear extrapolation and the prospect lives on.

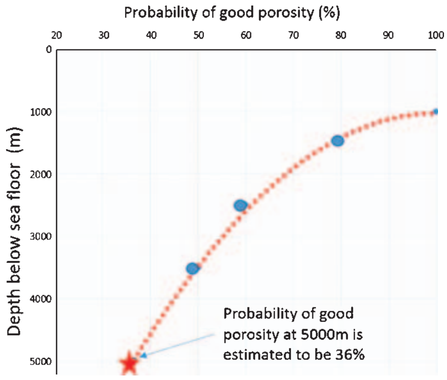

Figure 3. *Probability of effective reservoir (>15% porosity) vs depth below sea floor. A line of best fit is calculated from data points at 1500, 2500 and 3500 m (blue) and extrapolated to 5000 m. The extrapolated point (red star) gives a 36% chance of finding a reservoir with more than 15% porosity.*

So how does this method compare to the prospect review team? Well they chose 30%. But none of the review team could explain why.

Addendum: Following the June article on negative time I found this clock in the meeting room in the office of Total Depth Pty Ltd.

I don't know if it proves the existence of negative time but it does show how it is easy to be confused if common standards are ignored. Is it still the morning or is it the afternoon?

October			**2014**
21–23	131th SEGJ Conference http://www.segj.org	Shizuoka	Japan
26–31	SEG International Exhibition and 84th Annual Meeting http://www.seg.org	Denver	USA
27–29	KazGeo 2014: From Challenges to Opportunities http://www.eage.org	Almaty	Kazakhstan
December			**2014**
3–4	1st SEG/SBGf Workshop on Near Surface Geophysics Applied to Exploration, Engineering and Environmental Studies http://www.seg.org/meetings/Salvador2014	Salvador	Brazil
10–12	The 8th International Petroleum Technology Conference (IPTC) http://www.iptcnet.org	Kuala Lumpur	Malaysia
January			**2015**
11–14	3rd South Asian Geosciences Conference and Exhibition http://geo-india.com/	New Delhi	India
February			**2015**
15–18	ASEG–PESA 2015: *Geophysics and Geology together for Discovery* 24th International Geophysical Conference and Exhibition http://www.conference.aseg.org.au/	Perth	Australia
March			**2015**
18–21	PACRIM 2015 http://www.pacrim2015. ausimm. com.au	Hong Kong	China
May			**2015**
17–22	20th Caribbean Geological Conference http://www.thegstt.com	Port-of-Spain	Trinidad and Tobago
June			**2015**
1–4	77th EAGE Conference and Exhibition 2015 http://eage.org	Madrid	Spain
July			**2015**
7–10	2nd Near-Surface Geophysics Asia-Pacific conference (NSGAP) (website TBA)	Waikoloa Village (Hilton), Hawaii	USA
October			**2015**
18–23	SEG International Exhibition and 85th Annual Meeting http://www.seg.org	New Orleans	USA
December			**2015**
7–9	The 9th International Petroleum Technology Conference (IPTC) http://www.iptcnet.org	Doha	Qatar
October			**2016**
16–21	SEG International Exhibition and 86th Annual Meeting http://www.seg.org	Dallas	USA
July			**2017**
2–17 (TBC)	3rd Near-Surface Geophysics Asia-Pacific conference (NSGAP) (website TBA)	TBA	Australia

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2014 ASEG WINE OFFER

orders close Friday 7th of November 2014

The ASEG SA/NT Branch is pleased to be able to present the following wines to ASEG members. These wines were found by the tasting panel to be enjoyable drinking and excellent value. The price of each wine includes GST and bulk delivery to a distribution point in each capital city in early December. Stocks of these wines are limited and orders will be filled on a first-come, first-served basis.

Please note that this is a non-profit activity carried out by the ASEG SA/NT Branch committee only for ASEG members. The prices have been specially negotiated with the wineries and are not available through commercial outlets. Compare prices if you wish but you must not disclose them to commercial outlets.

2012 Reillys Shiraz

"Totally opaque black purple red colour with deep dark purple red hue. The nose offers up scents of liquorice over black-berry, dark plum and vanillin confectionary with some black pepper end notes. The palate is packed with richness and possesses an explosive power that belies its meagre price point yet has a more structured fruit profile than previous releases. Mouthfilling flavours of liquorice, black pepper, black cherry and blackberry with some underlying toasty vanillin oak. The black pepper persisting long into the aftertaste. Fine grained tannins but with plenty of structure. Superb persistence with long aftertaste of liquorice, black pepper and toasty vanillin oak."

ASEG PRICE $150/dozen (RRP $185)

2013 Hemera Riesling

Single Vineyard. Melon and lemon lift the spice from the French oak with supporting stone fruit flavours. Lees stirring has added creaminess to the mid palate that is round and crisp with nectarine and peach complimented with subtle flint and minerality and exceptional length.

ASEG PRICE $120/case (RRP $300)

Please order online at www.aseg.org.au (click on "Wine Offer") and pay by credit card, or fill in below order form

Name: ______________ Daytime telephone: (___) _______________ Email address ________________________

Address: ____ Capital city for collection: _____________

I would like to pay by: [ ] Cheque – payable to ASEG SA/NT Wine Offer (enclosed)

[ ] Visa [ ] Mastercard Card Expiry date: __ __ / __ __

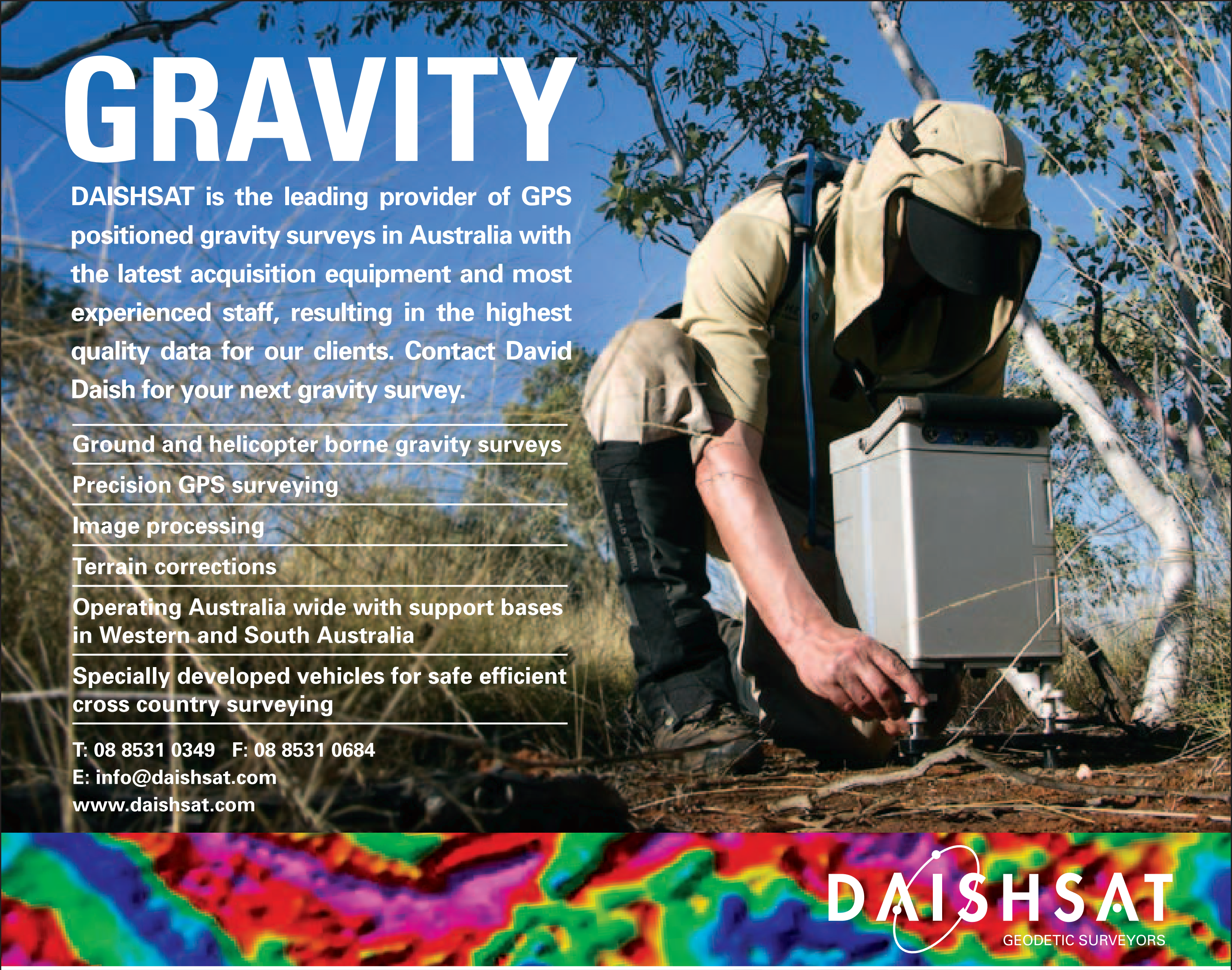
Card Account number: __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ Signature: __________________

Number of dozens	Wine	Price per Dozen	Total
	2012 Reillys Shiraz	$150	
	2013 Hemera Riesling	$120	
		TOTAL	

Order and payment to:

secretary@aseg.org.au T: 02 9431 8622 | F: 02 9431 8677 | PO Box 576, Crows Nest, NSW 1585

(Please follow up any faxes with a phone call to ensure the form has been received)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